Water Management Plan - Phase 1

Lesser Slave Lake and Lesser Slave River Basins

Lesser Slave Watershed Council

July 2009

EXECUTIVE SUMMARY

The Lesser Slave River originates at the outlet of Lesser Slave Lake, and flows easterly for 72 km to its confluence with the Athabasca River. Flows in the Lesser Slave River are directly impacted by water levels in Lesser Slave Lake. The average annual outflow from the lake is 1,369 million m^3, equivalent to a mean annual flow of 43.4 m^3 per second in the Lesser Slave River.

In 1983, a fixed-crest weir and eight cutoff channels were constructed in the upper reach of the Lesser Slave River. This project, known as the Lesser Slave Lake Regulation Project, was intended to reduce the severity of flooding of low-lying areas around the lake. As intended, the regulation project has stabilized water levels in the lake; mean lake water levels have decreased by about 0.3 m, and the overall fluctuation of lake water levels has been reduced from 3.5 m to 2.7 m. Although the effect of stabilizing water levels in the lake on downstream flows in the river was not directly considered in its design, the regulation project has altered flow rates in the river from the natural condition.

The Lesser Slave River is the source of water for municipal and industrial uses. The Lesser Slave River is also a regionally important fishery and a migratory link with Lesser Slave Lake and the Athabasca River. Eight key fish species have been identified in the Lesser Slave River and each species makes substantial use of the river for all or many of its life stages.

In November 1999 water levels in Lesser Slave Lake dropped to 575.43 m (below the weir crest elevation of 575.50 m). Flow over the weir on the Lesser Slave River virtually ceased from November 21-24, a situation that threatened water supplies and the health of the aquatic environment. Emergency measures, dredging of the channel at the lake outlet and installing siphons to convey water over the weir, had to be implemented to restore flow to the river.

In November 2006, a combination of silt, low temperatures and resulting ice formation blocked the flow to the river at the lake resulting in a blockage of flow at the weir. Once again, emergency measures (dredging and siphoning) had to be implemented.

The issue of low water levels in the lake and river first crystallized public concerns in the winter of 1999/2000. A group of citizens and stakeholders formed a Watershed Committee to take action on issues affecting the sustainability of Lesser Slave Lake. In 2007 this group became the Lesser Slave Watershed Council (LSWC), formally designated as a Watershed Planning and Advisory Council as part of the provincial *Water for Life* strategy.

This water management plan presents the recommendations of the Lesser Slave Watershed Council for addressing the issue of low flows in the Lesser Slave River. The water management plan involved the completion of four technical tasks to: (1) address present and future water uses; (2) address protection of the aquatic environment; (3) assess whether the Lesser Slave Regulation Project meets the needs of water users; and (4) assess the impact of sediment in the lake outlet channel.

Surface water in the Lesser Slave River basin has been allocated mainly for municipal and industrial uses. Water licenses held by Penn West, Slave Lake Pulp Corporation, the Town of Slave Lake, and the Municipal District of Lesser Slave River (Mitsue Industrial Park) presently account for 99 percent of the surface water allocation. The four major license holders have collectively withdrawn an average of 10,824,539 m^3 per year of water from the Lesser Slave River from 1993-2008. The maximum rate of water diversion from the river by the four major license holders is 0.65 m^3 per second; this represents less than 1.5 percent of the mean annual river flow (43.4 m^3 per second). Annual water withdrawal by the four major license holders from the Lesser Slave River is projected to average about 12,100,000 m^3 by 2020.

Ensuring an adequate water supply for industrial and municipal uses while protecting the aquatic environment of the Lesser Slave River is the primary purpose of the water management plan. At present, there is an inadequate understanding of the impact of low flow conditions on the aquatic environment. The Lesser Slave Watershed Council is therefore conducting a scientific assessment of instream flow needs (IFN) that, upon completion, will provide a greater understanding of the relationship between river flows and ecosystem components: hydrology, biology, geomorphology, connectivity and water quality. Completion of this scientific assessment will enable the LSWC to recommend a Water Conservation Objective (WCO), to reflect a balance between the ecological needs of the lake and river and the economic needs of water users.

In the interim, however, the issue of low flow conditions needs to be addressed. This plan recommends specific operational response procedures to ensure that a minimum flow of 6 m^3 per second is maintained in the Lesser Slave River. The recommended minimum flow is based upon an assessment of river flow and water quality during the low flow conditions of 1999-2000, and is considered the minimum flow required to ensure water supplies for municipal and industrial uses, including effluent dilution, and to maintain concentrations of dissolved oxygen above water quality guidelines at the mouth of the river.

A continual supply of sediment exists at the outlet of Lesser Slave Lake that is available for transport into the Lesser Slave River by littoral drift. When water levels in the lake are low, as in 1999 and 2006, the lake outlet can become blocked with sediment; dredging had to be undertaken by the Municipal District of Lesser Slave River to restore flow to the river channel above the weir. Also, siphons had to be installed on top of the weir to restore flow to the river channel downstream.

In the future, to ensure that a minimum flow of 6 m^3 per second is maintained in the Lesser Slave River, the LSWC recommends that Alberta Environment (AENV) take the lead role and responsibility for implementing the low flow operational response procedures as outlined in this water management plan.

Specifically, the LSWC recommends that AENV be responsible for obtaining the regulatory approvals necessary for dredging of the channel at the lake outlet to ensure a minimum flow of 6 m^3 per second is maintained in the Lesser Slave River. AENV would also be responsible for lining up the needed equipment and overseeing the dredging operation. Costs of the dredging would be shared with the four major water users.

The future use of siphons to maintain flows in the river (downstream of the weir) under low flow conditions is not recommended due to safety considerations and long lead times required for installation and commissioning. Therefore, the LSWC recommends that AENV proceed with the design and construction of gated culverts, for installation in the plug in the old river channel, to accommodate the minimum flow past the weir.

To ensure that concentrations of dissolved oxygen in the river are maintained above water quality guidelines during low flow conditions, the LSWC recommends that AENV initiate monitoring when flow in the river is below 12 m^3 per second. The LSWC also recommends that AENV establish a long-term water quality monitoring station on the Lesser Slave River.

This water management plan for the Lesser Slave River Basin presents the recommendations of the Lesser Slave Watershed Council for addressing the issue of low flows in the Lesser Slave River. The plan reflects public input and has been submitted to the Minister of Environment for review and approval. Alberta Environment has regulatory responsibility for allocating water and protecting the aquatic environment (*Water Act*) and for controlling wastewater releases into the environment (*Environmental Protection and Enhancement Act*).

Lesser Slave River

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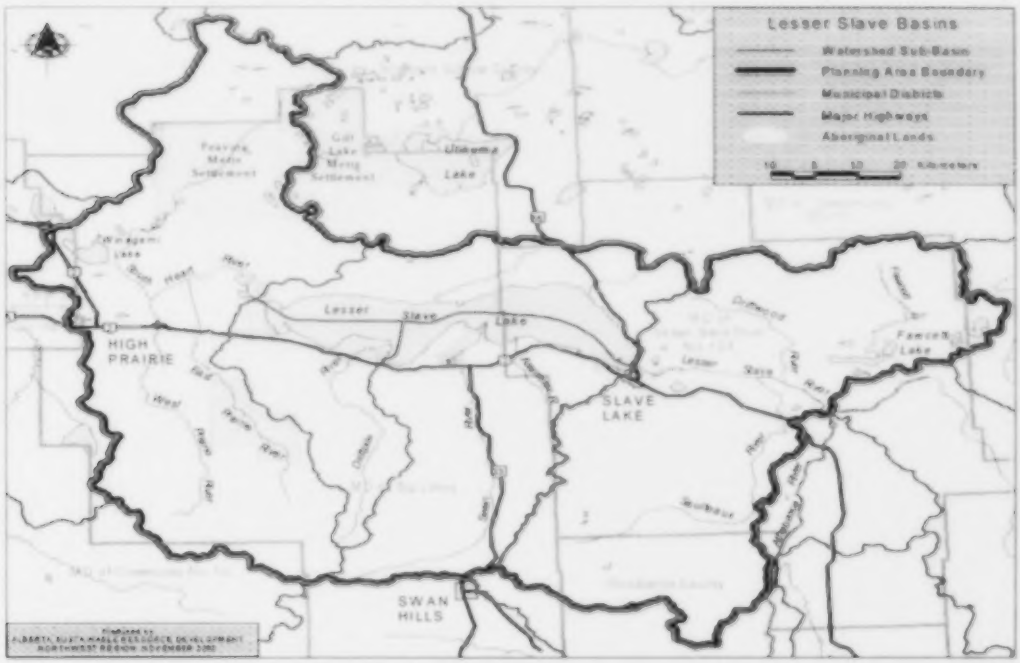
1. INTRODUCTION

Lesser Slave Lake is the third largest lake in Alberta (1,160 km^2) and is part of the Athabasca River system.

The Lesser Slave watershed has an area of 33,700 km^2 and consists of two major sub-watersheds or sub-basins: the Lesser Slave Lake Basin and the Lesser Slave River Basin.

Figure 1: Lesser Slave Lake Basin and Lesser Slave River Basin Planning Area



The Lesser Slave Basins provide a water supply for industrial, municipal, domestic and agricultural users, and have provincially significant fishery and ecological values.

The water levels of Lesser Slave Lake have fluctuated significantly over the past 12 years, from record highs of 577.1 m to record lows of 575.3 m. These fluctuations in water levels affect recreation and tourism, agriculture, commercial and sport fisheries, and municipal and industrial water supplies.

The Lesser Slave Basins have a history of water management concerns, mainly related to periodic flooding of agricultural land in the low-lying and delta areas surrounding the lake. In the 1960s, the lower reaches of the East and West Prairie rivers were straightened and dikes were constructed in the Buffalo Bay-Horse Lakes area to reduce flooding of farmland; river cutoff channels and dikes were also constructed along the Swan River for similar purposes. In 1983, in order to stabilize water levels in the lake and decrease the impact of flooding, a fixed-crest weir

and eight cutoff channels were constructed in the upper reach of the Lesser Slave River (Lesser Slave Lake Regulation Project).

Flows in the Lesser Slave River are directly impacted by the water levels in Lesser Slave Lake; low water levels in the lake can critically affect municipal and industrial water supplies and the capacity of the river to dilute effluents. In late 1999, water levels in the lake dropped to the level of the weir crest at the outlet, resulting in a disruption of flow into the Lesser Slave River, an event that had never before been recorded.[1] The situation threatened water supplies and the aquatic environment. Emergency measures had to be taken to restore flow in the river.

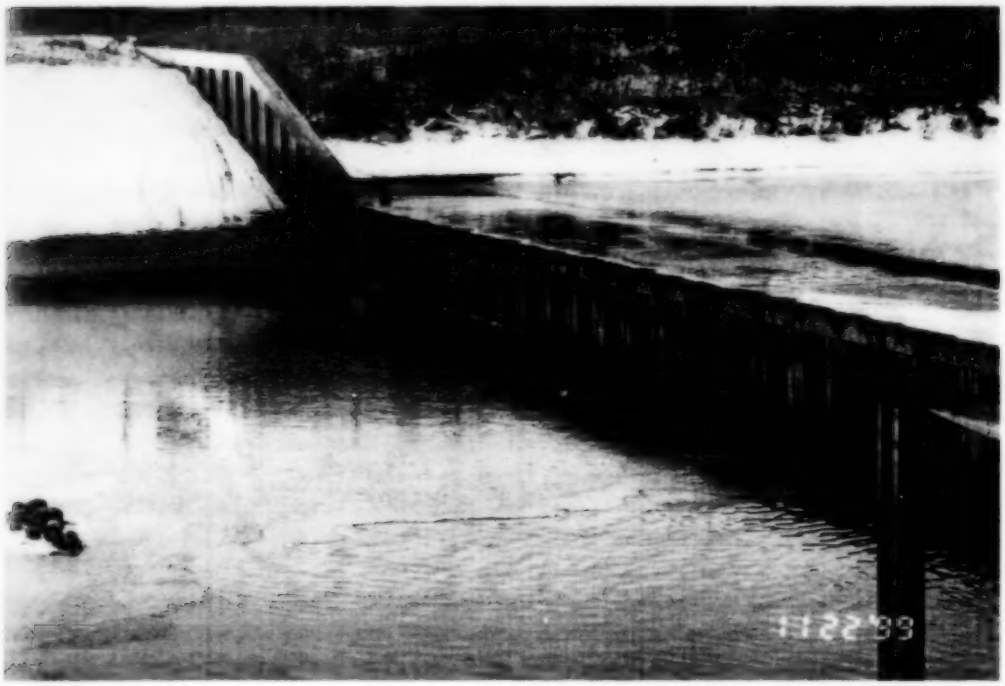


Figure 2 Flow of Lesser Slave River Blocked at the Weir November 22 1999

The issue of low water levels in the lake crystallized public and stakeholder concerns and led to the formation of a Watershed Committee to take action on issues affecting the sustainability of Lesser Slave Lake. In 2007, this group became the Lesser Slave Watershed Council (LSWC), formally designated as a Watershed Planning and Advisory Council (WPAC) under the provincial *Water for Life*[2] strategy.

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[1] *Low Flow Conditions in the Lesser Slave River*, 1999-2000, Leigh Noton and Michael Seneka (August 2000).
[2] *Water for Life* Strategy, Government of Alberta (November 2003).

1.1 The Issue of Low Flows in the Lesser Slave River

Due to extremely low water levels (575.43 m) in Lesser Slave Lake, flow over the outlet weir on the Lesser Slave River virtually ceased from November 21-24 1999 (Figure 2). This situation threatened municipal and industrial water supplies and the aquatic environment. Emergency measures were implemented by the Municipal District (MD) of Lesser Slave River, in partnership with the other water licensees, to restore flow to the river. Such measures included dredging a channel at the lake outlet to ensure a water supply for the Town of Slave Lake, and installing siphons (Figure 3) to divert water over the weir to supplement low flows for downstream industrial water supplies and for dilution of effluents. The licensed temporary water diversion restored flow to the river below the weir. The total amount of flow past the weir from November 25, 1999 to April 18, 2000 was about 53.2 million m^3, a volume of water equivalent to a mean daily discharge of 4.2 m^3 per second for the period, or about 46 mm depth on the lake.[3]

Figure 3 Siphoning of River Flow over the Weir

Alberta Environment initiated monitoring and assessment of river flow and water quality in the winter of 1999-2000, and completed an initial assessment of the impact of diversions.[4] Continuous daily monitoring data showed that dissolved oxygen (DO) concentrations did not meet the chronic (6.5 mg/L) or acute (5 mg/L) guidelines for the protection of aquatic life[5] for a period in late November to early December 1999. DO concentrations as low as 1.8 mg/L were measured at the mouth of the river. An accidental glycol spill may have contributed to the sag in DO. After the temporary diversions restored flow over the outlet weir, DO concentrations in the river recovered but remained lower than average for the rest of the winter.

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[3] *Low Flow Conditions*, 3.
[4] Ibid., 1-10.
[5] *Surface water quality guidelines for use in Alberta*, Alberta Environment, Pub. No. T/483 (1999).

Low flow conditions occurred again in fall 2006. In late October, the MD of Lesser Slave River notified Alberta Environment of the likelihood of low river flows for the upcoming winter, and initiated its contingency water supply plan. Early in November, low temperatures resulted in the formation of ice in the lake outlet channel; high winds caused a buildup of ice floes that blocked flows to the river. The MD of Lesser Slave River was issued the provincial and federal government approvals needed to undertake dredging of the river channel at the lake outlet and installing siphons on top of the weir.

The dredging of the lake outlet channel effectively restored flows to the river. About 4000 m^3 of silt and sand was excavated and stockpiled on the south side of the channel within the lake. The MD of Lesser Slave River intended to remove this material by truck and loader when the ice reached a thickness to safely allow it, but due to weather and site conditions the ice never thickened to the required depth and the excavated materials were not removed. The MD then had to look at alternate methods for removal of the dredged materials to meet the requirements of three regulatory agencies.

After receiving authorizations from the three provincial and federal agencies, the MD of Lesser Slave River commenced operations in late May 2007 to remove, dewater and dispose of the dredging spoil material from the lake. Spoil piles were marked with buoys to meet navigation requirements. When the dredging operations were not completed by the May 31 deadline set in their authorizations, MD personnel were threatened with prosecution under federal legislation.

The MD of Lesser Slave River subsequently recommended that when similar situations occur in the future, Alberta Environment should assume the responsibility for ensuring water flow in the river.

1.2 Purpose of Plan, Phase 1

The purpose of the Phase 1 water management plan is to address the issue of low flow conditions in the Lesser Slave River; specifically, how to ensure an adequate water supply for municipal and industrial users while protecting the aquatic environment.

1.3 Plan Goals and Tasks

Four goals were identified for the Phase 1 plan:

- Address present and future water uses.
- Address protection of the river aquatic environment.
- Assess whether the Lesser Slave Lake Regulation Project meets the needs of water users.
- Assess the impact of sediment in the Lesser Slave Lake outlet channel.

Four technical tasks were undertaken to meet the plan goals (Section 3 of the plan).

1.4 Legislation and Policy Context

Alberta Environment has regulatory responsibility for allocating water and protecting the aquatic environment, and for controlling wastewater releases into the environment.
Specifically, the plan is controlled, guided or influenced by the following legal and policy documents:

- *Water Act* (RSA 2000, c. W-3).
- *Environmental Protection and Enhancement Act* (RSA 2000).
- *Alberta's Commitment to Sustainable Resource and Environmental Management* (2000).
- *Framework for Water Management Planning* (2001).
- *Buffalo Bay/Horse Lakes East West Prairie Rivers Water Management Program* (1992).
- *Public Lands Act* (RSA 2000).
- *Wildlife Act* (RSA 2000).
- *Fisheries Act*.
- *Navigable Waters Act*.

1.5 Public Involvement

The Lesser Slave Watershed Council (LSWC) includes representation from rural (MD of Big Lakes, MD of Lesser Slave River) and urban (Town of High Prairie, Town of Slave Lake) municipalities, First Nations (Lesser Slave Indian Regional Council) and Metis Settlements, citizens and stakeholders from various sectors including agriculture, forest industry, oil and gas industry, tourism, commercial fishermen, cottage owners, environmental non-government organizations, and the provincial and federal government.

As a Watershed Planning and Advisory Council (WPAC) established under the provincial *Water for Life* strategy, the LSWC is mandated to engage citizens and stakeholders in watershed management planning. Completion of the Phase 1 water management plan for the Lesser Slave River is an important first step in addressing key issues in the watershed. Future phases of planning will be focused on issues specific to Lesser Slave Lake and its watershed.

In the process of completing the Phase 1 plan, the LSWC has served as a forum for discussion and sharing of information to address the issue of low flows in the Lesser Slave River. The LSWC has also held open houses to obtain public input on the water management plan. Input from municipal and aboriginal councils was also sought in the review of the management plan. The LSWC also recognizes public input from previous planning initiatives conducted in the watershed.

1.5.1 Plan Review and Public Input

The Terms of Reference for the Water Management Plan[6] were reviewed by the public, municipal councils, the Lesser Slave Watershed Committee, and the Lesser Slave Indian Regional Council.

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[6] *Approved Terms of Reference*, Water Management Plan for Lesser Slave Lake and Lesser Slave River Basins Phase 1 (July 2003)

Public input on the Terms of Reference was obtained at open houses held in 2003 in High Prairie, Slave Lake and Faust. A wide range of concerns were raised including:

- Siltation at the lake outlet and at the weir.
- Modifications to the weir to further stabilize water levels in the lake (benefits and risks).
- Sedimentation of the lake from land uses (accelerated runoff and soil erosion) in the watershed and from straightening of river channels.

Meetings were held with First Nation councils (Sawridge, Swan River, Driftpile, Sucker Creek and Kapawe'no) and contacts on the purpose and scope of the plan, and on the information that the plan would be based on. A special information meeting was also held with the Driftpile First Nation Council. Several concerns were raised by the First Nation councils, including:

- Unregulated dumping of oilfield drilling waste.
- Development of lakeshore land; effects on fish habitat and water quality.
- Effectiveness of the Lesser Slave Lake Regulation Project.
- Effects of Swan River channelization and flood control projects.
- Use of water for oilfield injection purposes.
- Sedimentation and barriers to fish passage from road crossings.
- Deterioration of lake water quality and concern with drinking water supplies and the lake fishery.
- Sedimentation of the Lesser Slave Lake and Buffalo Bay.

Meetings were subsequently held with First Nation Councils on the draft Phase 1 water management plan.

Presentations on the draft management plan were made to the municipal councils of the Town of Slave Lake, the Town of High Prairie, the MD of Big Lakes and the MD of Lesser Slave River. There was general support for the plan document.

Open houses on the draft management plan were held in Slave Lake, High Prairie, and Joussard in May 2009. Although there was general public support for the plan recommendations for dealing with the issue of low flow conditions in the Lesser Slave River, concern was expressed that a greater focus needed to be placed on dealing with issues related to the lake and its watershed.

1.5.2 Previous Planning Initiatives and Outcomes

Lesser Slave Regulation Project

In response to pressure from local residents in the 1970's to reduce the impact of flooding in the Lesser Slave Lake basin, Alberta Environment studied various lake regulation alternatives. Local residents participated through public meetings and through a local public advisory committee. The Lesser Slave Basin Advisory Committee oversaw the implementation of the Lesser Slave Lake Regulation Project.

Open houses were held on water levels in Lesser Slave Lake (August/December 1993)[7] to discuss concerns about the impacts of the Regulation Project, and on the issues of lake sedimentation and water quality, lake levels and regulation, future shore land development, protection of the aquatic environment, and sustainability of the fishery.

Buffalo Bay/Horse Lakes Water Management

The Buffalo Bay-Horse Lakes Public Advisory Committee reviewed issues and made recommendations on water management issues in the Buffalo Bay-Horse Lakes area.[8]

Iroquois Creek Basin Study

The Iroquois Creek Basin Study (1985)[9] considered drainage and flooding problems associated with land clearing and on-farm drainage improvements of the early 1970's. Landowners were interviewed and a drainage plan was produced that provided for future agricultural development, including the delineation of a 1:10 year level of flood protection for the basin. Reservations were subsequently place on Crown lands for watershed protection, and to prevent further land development that could increase the potential for flooding in the lower portion of the basin.

Frost Hills Local Integrated Resource Plan

The Frost Hills Local Integrated Resource Plan (1985)[10] was initiated in response to local demands for an expanded agricultural land base involving provincial Crown lands. Five land use zones were delineated, defining objectives for agriculture, grazing, lakeshore and stream conservation, and multiple-use.

2.0 OVERVIEW OF RIVER AQUATIC ENVIRONMENT

2.1 Hydrology

The Lesser Slave River originates at the outlet of Lesser Slave Lake, and flows in an easterly direction for 72 km to its confluence with the Athabasca River. The drainage area between the outlet of Lesser Slave Lake and the mouth of the Lesser Slave River is 6535 km^2. Major tributaries include Sawridge Creek, Otauwau River, Saulteaux River and Driftwood River.

Due to the large surface area (1,160 km^2) of the lake and the large net contributing watershed area (12,410 km^2) to the lake, the flow in the Lesser Slave River does not typically fluctuate widely on a seasonal basis. The large catchment or watershed area of Lesser Slave Lake can cause significant fluctuations in lake water levels arising from extreme runoff events. Inflow rates can far exceed normal outflow capacity, resulting in rapid increases in lake water levels.

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[7] *Lesser Slave Lake Regulation Project*, Information Updates, July/December 1993.
[8] *Buffalo Bay/Horse Lakes-East/West Prairie Rivers Water Management Program*, Alberta Environment, Sept 1992.
[9] *Iroquois Creek Basin Study*, 1985
[10] *Frost Hills Local Integrated Resource Plan*, 1985

The rapid decline of water levels in the lake from 1997 to 2000 was a direct result of very low runoff conditions in the watershed.

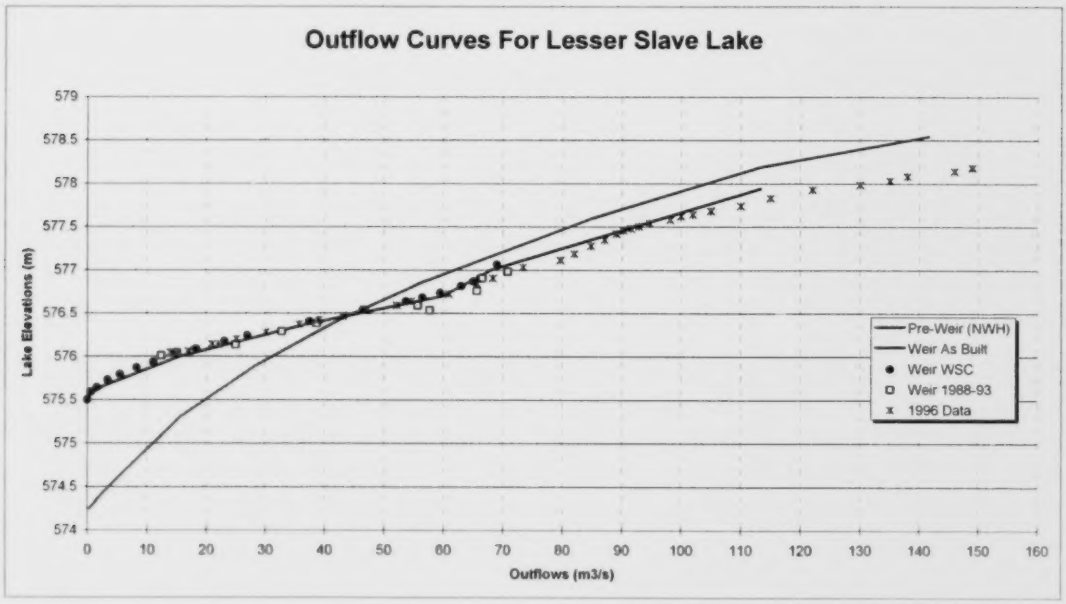
Water Balance

In general, inflows and outflows dominate the water balance of Lesser Slave Lake.[11] On average, surface runoff accounts for 80 percent of the annual flow (1,532 million m^3 per year) to Lesser Slave Lake; direct precipitation accounts for the other 20 percent (545 million m^3 per year). Gross lake evaporation averages 708 million m^3 per year. The average annual outflow from the lake is 1,369 million m^3, equivalent to a mean annual river flow of 43.4 m^3 per second.

Lesser Slave Lake Regulation Project

In 1983, a fixed-crest weir and eight river cutoff channels were constructed in the upper reach of the Lesser Slave River. The intent of the regulation project was to reduce the severity, both in frequency and duration, of the relatively common flooding of low-lying areas around the lake. The impact on the lake has been a decrease in mean water levels of approximately 0.3 m, and a reduction of the overall fluctuation of water levels from 3.5 m to 2.7 m.[12]

Although the effect of lake stabilization on downstream river flows was not directly considered in its design, the regulation project effectively modified the flow rate out of the lake into the Lesser Slave River from the natural outlet condition (Figure 3).



[11] *Hydrology of the Lesser Slave Watershed*, Michael Seneca, AENV, 2004.
[12] *Lesser Slave Lake Regulation Status Report*, AEP, July 1993/Information Update 2000.

Figure 4[13]

Recorded Flows

Since 1915 Lesser Slave River flows had been measured and recorded, at various times and locations, at or near the outlet of the lake. Since 1988, flow in the river has been measured at the Water Survey of Canada (WSC) gauge located at the outlet weir just downstream of the Highway 88 Bridge.

Naturalized vs. Regulated Flows

Since 1983, flows recorded on the main stem of the Lesser Slave River have reflected the effects of the Lesser Slave Lake Regulation Project. For subsequent hydrologic analyses, including an evaluation of the effects of regulation, data for lake water levels and river flows had to be simulated to reflect the pre-weir (naturalized) and post-weir (regulated) conditions for the period of record.

Upon a comparison of the naturalized and regulated flow regimes, very little change has been observed in mean annual river flows. The 2-year to 10-year flood flows would be expected to increase under the regulated flow regime, whereas flows for more infrequent floods with return periods greater than 10 years would be expected to decrease. The effects of regulation would be expected to increase the 2-year low flow but decrease the 10-year and high return period low flows.[14]

2.2 River Channel Morphology

Ongoing natural processes such as sediment transport, erosion and deposition are primarily responsible for the evolution of the Lesser Slave River into its present form. However man-made alterations (weir and cutoffs) have altered the river channel in its upper reach.

The overall river slope is largely controlled by Lesser Slave Lake and the presence of a cobble-paved bed at the Saulteaux Rapids 48 km downstream from the lake.[15]

The Otauwau River confluence marks the beginning of the change from the flatter upstream reaches of the Lesser Slave River to the higher gradient reaches downstream of the Saulteaux Rapids. From the Saulteaux Rapids downstream to the Athabasca River confluence, there is a marked increase in the slope of the river channel (average slope of 0.7 m/km); in this reach the river is wider (75-100 m) and has a mainly gravel bed. Above the Saulteaux Rapids the river channel averages 50-60 m in width and has an average slope of 0.1 m/km and a mostly sandy bed. The upper 20 km of the river has become entrenched with ancient glacial lake bottom

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[13] *Outflows for Lesser Slave Lake*, Jim Choles, AENV, personal comm. 2008.
[14] *Lesser Slave River Instream Flow Needs Scoping Study*, Golder Associates, March 2004.
[15] *Instream Flow Needs Scoping Study*, 22.

sediments, derived mainly from littoral drift in Lesser Slave Lake; little of the bed sand material has been derived from the river bank.[16]

A post-construction assessment (1984) of the Lesser Slave Lake Regulation Project indicated aggradation of the river channel bed upstream of the weir due to the influence of the weir on channel hydraulics and reduced sediment transport capacity. Degradation of the channel bed downstream of the weir was attributed to the effect of the cutoffs on channel hydraulics and increased sediment transport capacity. In the reach of the river affected by the channel cutoffs the average slope had increased from 0.10 m/km to 0.14 m/km. Downstream of the cutoffs there had been only minor aggradation of the channel bed due to an increased rate of sediment transport through the cutoff reach. It was concluded there had been no significant change in channel thalweg (line of maximum depth) or bank erosion rate, due to a decreased flood peak regime, and no change in the annual bank transport rate.[17]

An assessment conducted in 1999 indicated a general trend toward adjustment of the river channel to its natural slope slowly progressing through the cutoff reach. In the 17.5 km reach downstream of the weir, 5.5 km had been aggraded and 12.0 km had been degraded. It was concluded that the river channel downstream of the lake outlet had been slowly adjusting to attain an equilibrium condition.[18]

2.3 Water Quality

The water quality of the Lesser Slave River normally reflects the quality of water in the outflow of Lesser Slave Lake. The influences of tributary streams, municipal discharge and pulp mill effluent on water quality can be greater during low flow conditions. The river receives treated municipal effluent discharge via Sawridge Creek, and treated (oxygenated) pulp mill effluent discharge. The river also receives runoff from agricultural land. The dilution capacity of the river is lowest during the winter months.[19]

Alberta Environment has collected water quality data at several sampling locations on the Lesser Slave River since the 1960s. Slave Lake Pulp Corporation (SLPC) has conducted baseline and operational monitoring since the 1990s, including monitoring to meet Environmental Effects Monitoring (EEM) requirements.

The *Surface Water Quality Guidelines for Use in Alberta* (ASWQG)[20] have been used to evaluate water quality conditions in the Lesser Slave River.[21]

Considerable data (154 samples) has been collected in the lower reach (Driftwood River to Athabasca River confluence) of the river since 1980. This reach tends to be well-oxygenated, with the notable exception of the low flow conditions of 1999-2000. Water temperatures have

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[16] Ibid, 23-24.
[17] *An Assessment of the Impact of Cutoffs and Weir on River Regime, and Recommended Monitoring Program-Lesser Slave River below Lesser Slave Lake Outlet*, Northwest Hydraulic Consultants Ltd., 1984.
[18] Alberta Environment 1999.
[19] *Low Flow Conditions*, 4.
[20] *Surface Water Quality Guidelines for Use in Alberta*, 1999
[21] *Instream Flow Needs Scoping Study*, 34.

generally been within the recommended criteria for mountain whitefish, the most temperature-sensitive fish species in this ecosystem. Maximum total phosphorus (TP) concentrations have been above the chronic guideline for aquatic life (0.05 mg/l) in all seasons, and median values have been slightly above the guideline in spring and summer.[22]

Considerable data (174 samples) also exists for the river reach downstream of the pulp mill effluent discharge. Median TP concentrations have been above the chronic aquatic life guideline in spring; maximum TP concentrations have been above the chronic guideline in all seasons.[23]

In the river reach above the weir, 69 samples have been taken since 1980, most of them in winter. Median TP concentrations have generally increased from winter to fall. Maximum TP concentrations have been above the chronic guideline in summer.[24]

Low Flow Conditions

During the extremely low flow conditions during the fall and winter of 1999-2000, water quality in the river was influenced more by the tributaries and effluents than is typical. The results of an enhanced monitoring effort indicated that many water quality variables remained within guidelines, and were not notably affected by effluent discharges. Some variables were increased by effluent discharges, but concentrations remained within guidelines. E. coli and fecal coliform bacteria counts increased somewhat due to effluent discharges. A few variables (dissolved oxygen, color, cadmium, zinc, phosphorus and nitrogen) were affected by effluent discharges and exceeded guidelines due to minimal dilution. The situation revealed that flow reductions in the river can have direct effects on water quality by a reduced assimilation capacity, an increased potential for macrophyte and algal growth, and increased dissolved ions from groundwater sources.[25]

2.4 Riparian Vegetation

Riparian vegetation is a key component of the river ecosystem. The vegetation along the Lesser Slave River is mainly deciduous forest, flanked primarily by wetlands. The riparian forests are dominated by aspen, with white spruce sub-dominant. Tertiary species include balsam poplar and paper birch. The distribution of trees can be viewed as an indicator of riparian health.[26]

The upper segments of the Lesser Slave River have been straightened by cutting off meander bends. The oxbows and large meanders are presently drying up and remain as meadows or are barren of vegetation. In the river segment above the weir, vegetation has become established on formerly submerged areas. The presence of the weir limits the water available to the oxbow lakes in the upper river segment.[27]

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[22] Ibid, 36.
[23] Ibid, 38.
[24] Ibid, 40.
[25] *Low Flow Conditions*, 4-9.
[26] *Instream Flow Needs Scoping Study*, 75.
[27] Ibid, 72-73.

However, substantial changes to riparian vegetation have not occurred as a result of the weir and cutoffs. Fragmentation of riparian habitat from forest harvesting, residential and agricultural development, and highway development have had the greatest impact.[28]

2.5 Aquatic Species

From Lesser Slave Lake to the Saulteaux River confluence, the Lesser Slave River is a low gradient sand-bed stream. In its lower reaches, however, the river is characterized by riffle and pool sequences and gravel and cobble substrates.

River flow is one of the major determinants of benthic invertebrate habitat, through its influence on channel morphology, substratum characteristics, velocity and water quality. Benthic habitat in the upper reaches of the river is mainly depositional with the slower velocity and fine-grained bottom sediment. The higher gradient lower reaches of the river have a greater proportion of erosional habitat; the shift from depositional to erosional habitats begins near the Otauwau River confluence.[29]

There have been twelve studies of benthic invertebrate communities of the Lesser Slave River since 1989. A total of 47 sites (20 in depositional habitats, 27 in erosional habitats) have been sampled, over half of them in the river segment immediately upstream and downstream of the pulp mill effluent discharge. The data has been used for monitoring and assessment of the pulp mill operation, including the Environmental Effects Monitoring (EEM) required by Environment Canada.[30]

The Lesser Slave River provides a regionally important fishery and a migratory link with Lesser Slave Lake and the Athabasca River. The river has complex fish movement patterns with fish moving to and from the lake, inflowing tributaries, and the Athabasca River.[31]

Fifteen fish species have been documented in the main stem of the river (seven sport species, two sucker species, and six small-bodied forage species). Eight key fish species have been identified for the Lesser Slave River: walleye, northern pike, lake whitefish, mountain whitefish, goldeye, longnose sucker, white sucker, and various species of shiner. Each species makes substantial use of the river for all or many of its life stages (spawning, nursery, rearing, feeding, overwintering, migration). Walleye is ranked as a sensitive species of special concern in Alberta; there is evidence of a decline in their abundance in the Lesser Slave watershed. Longnose sucker is abundant, especially in the upper reaches of the river, and has been selected as a key indicator for examining the potential impacts of pulp mill effluent.[32]

It was formerly assumed that many fish species moved to Lesser Slave Lake or to the Athabasca River to overwinter. However, northern pike have shown a high level of use of the river in

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[28] Ibid, 77.
[29] Ibid, 65.
[30] Ibid, 53-55.
[31] Ibid, 78.
[32] Ibid, 78-103.

winter, and overwintering by other species cannot be ruled out. Deep pools in the lower reach of the river and thermal refugia from groundwater inflow may provide important winter habitat. Mature mountain whitefish are thought to spawn in the main stem of the river in the fall.[33]

3.0 TECHNICAL ASSESSMENTS AND FINDINGS

Four technical tasks were completed in the development of the Phase 1 water management plan.

Task 1 (Future Water Uses) was completed by a technical sub-committee of the Lesser Slave Watershed Committee.[34]

Task 2 (Instream Flow Needs) was completed by an interdepartmental technical committee, including representation from the Lesser Slave Watershed Committee.

Task 3 (Sedimentation in the Lesser Slave Lake Outlet Channel) assessed the effect of sediment in the outlet channel on the function of the weir, the function of the channel, the flow regime upstream and downstream of the weir, and on downstream water users.

Task 4 (Weir Configuration Impacts) assessed the impact of various weir configurations on lake water levels, river flows and aquatic ecosystems.

3.1 LESSER SLAVE RIVER BASIN: WATER ALLOCATION AND USE

3.1.1 Water Allocation

Alberta's *Water Act* requires all industrial, municipal, agricultural and other non-domestic water users to obtain a license to divert and use an annual allocation of water. Licensed allocations are based on the expected maximum volume of water that may be required annually and therefore do not represent actual water use.

To date a total annual volume of 14, 575,427 m^3 of water has been allocated to licensed water users in the Lesser Slave River basin; 95 percent of the total allocation has been from surface water sources, and only 5 percent has been from groundwater sources.

Surface Water

A total volume of 13,484,796 m^3 has been allocated in the river basin; this amount represents only 1 percent of the mean annual discharge (1,369 million m^3) of the Lesser Slave River at the outlet of the lake.

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[33] Ibid, 104-105.
[34] *Future Water Uses Task Report*, Lesser Slave Watershed Committee, June 2004.

Surface water in the river basin has been allocated mainly for oilfield injection, pulp production and municipal supply (Figure 5).

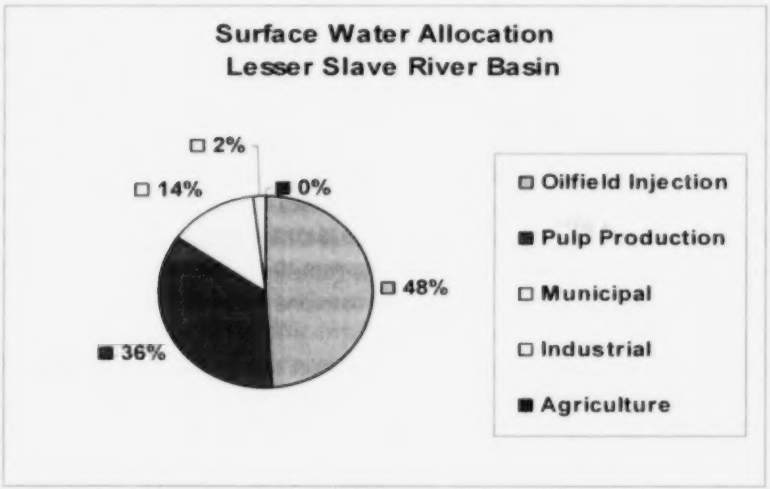


Figure 5

Groundwater

A total annual volume of 690,631 m^3 of groundwater has been allocated in the river basin. This amount represents only 5 percent of the total water allocation for the river basin. Groundwater has been mainly allocated for waste treatment (Swan Hills) and for oilfield injection (Figure 6).

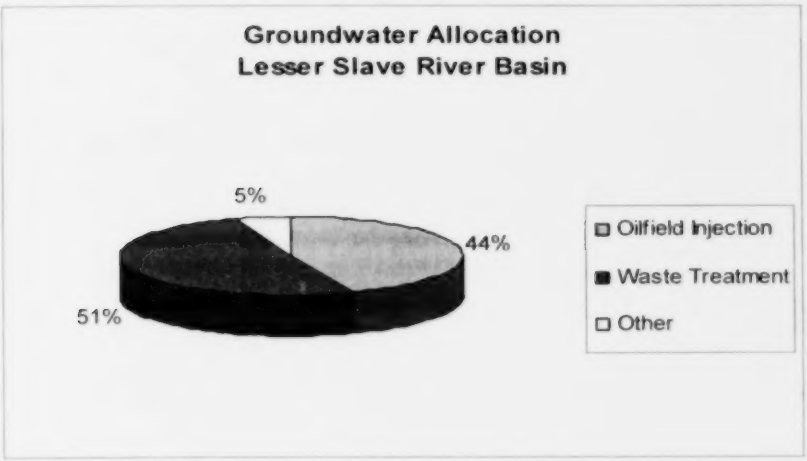


Figure 6

3.1.2 Present Water Use[35]

Surface Water

Water licenses held by Penn West Energy Trust, Ranger Slave Lake Pulp, MD of Lesser Slave River (Mitsue Industrial Park), and the Town of Slave Lake account for 99 percent of the surface water allocation in the river basin. These four license holders have collectively withdrawn an average of 10,824,539 m^3/year of water from the Lesser Slave River from 1993-2008 (Figure 7).

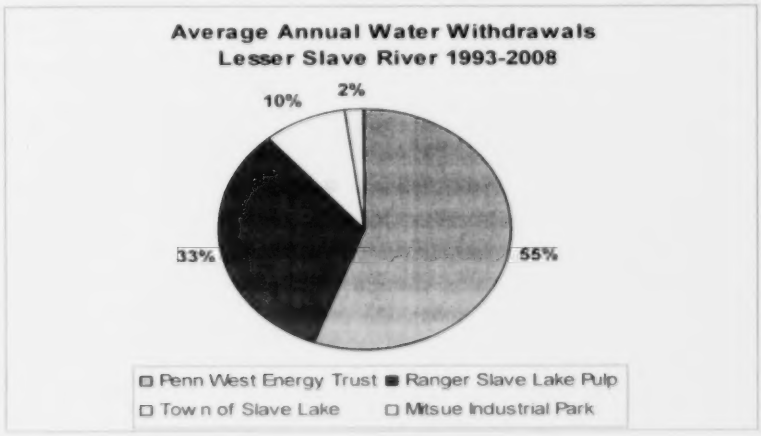


Figure 7

[35] In this report 'water use' represents the actual volume of water that is diverted or withdrawn from a specific source; it does not represent 'water consumption' in the sense that Consumption=Diversion-Loss-Return Flow. Data has been compiled from annual water diversion reports submitted to AENV by the license holders.

Water withdrawals by the four major license holders are summarized in Table 1. Return flows have averaged 90 percent of withdrawals for Ranger Slave Lake Pulp, and the Town of Slave Lake has returned more water to the river than its has withdrawn.

Licence	Purpose	Allocated Volume m^3/year	Average Withdrawal m^3 (1993-2008)	Average Return m^3 (1993-2008)
Penn West Energy Trust	Oilfield Injection	6,784,170	6,006,106	432,780
Ranger Slave Lake Pulp	Pulp production	4,932,430	3,575,730	3,207,065
Town of Slave Lake	Municipal water supply	1,850,230	1,028,553	1,155,005
Mitsue Industrial Park	Industrial water supply	246,700	214,150	0

Table 1

The maximum permitted rate of water withdrawal from the river by the four major license holders is 0.65 m^3 per second; this represents less than 1.5 percent of the mean annual river flow.

Groundwater

Nineteen groundwater licenses are located within the river basin for purposes of waste treatment (Swan Hills), oilfield injection, water supply (Marten Beach, Fawcett Lake), chemical manufacture, wood processing and stock watering.

3.1.3 Future Water Use

Penn West Energy Trust

Water has been withdrawn from the Lesser Slave River since 1968 for purposes of enhanced oil recovery (Figure 8).

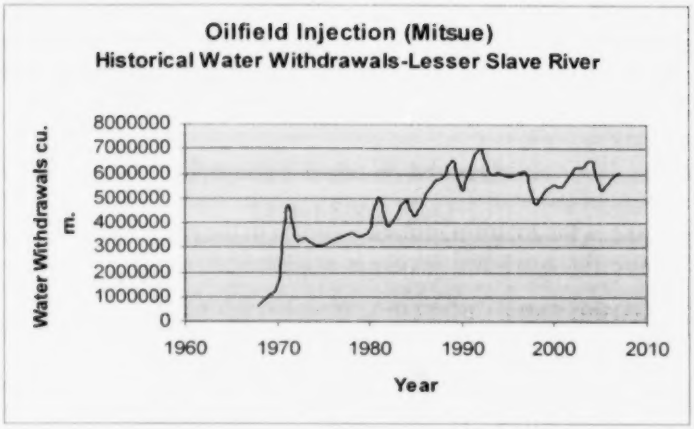


Figure 8

Penn West Energy Trust is the present water license holder (previous license holders for the Mitsue oilfield injection operation were Canetic, Acclaim and Chevron Texaco). The amount of water withdrawn from the river in 2008 (5,361,719 m^3) was about 700,000 m^3 less than in 2007. Penn West is currently evaluating alternative water supplies for the Mitsue operation.[36]

Ranger Slave Lake Pulp

From 1993-2007 pulp production rose from 116,345 ADMT to 217,173 ADMT, an increase of 46 percent. As a result the volume of water withdrawn from the Lesser Slave River for pulp production and cooling purposes also increased during this period, from 2,240,005 m^3 in 1993 to 4,078,652 m^3 in 2007 (Figure 9).

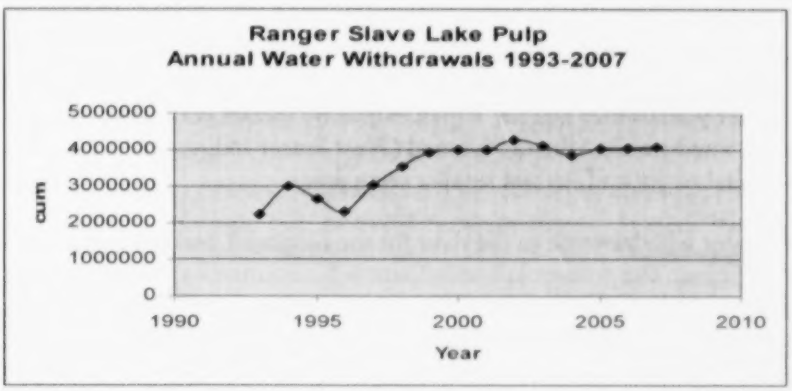


Figure 9

Water use in 2007 was 18.8 m^3 per ton of pulp (12.3 m^3 per ton was for pulp processing purposes and 6.5 m^3 per ton was for cooling purposes).[37] In 2004 the company indicated that, although

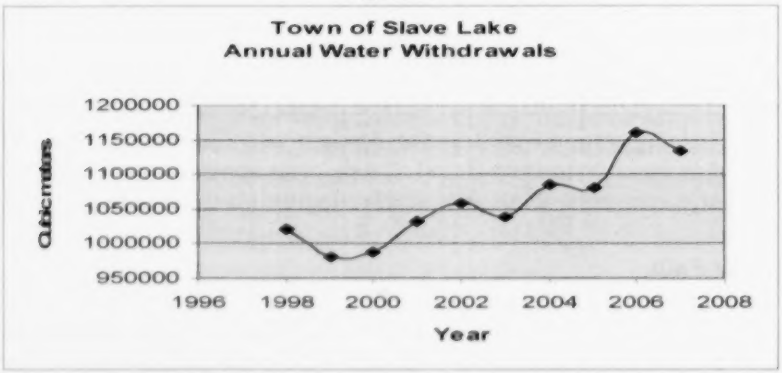
[16] Penn West Energy Trust, personal communication.
[17] Ranger Slave Lake Pulp, Annual Water Diversion and Return Summary, 2007.

more efficient use of water would be expected to continue, the volume of water withdrawn from the river would still increase in the future in anticipation of increased pulp production. Therefore water withdrawals from the river were projected to increase to a maximum of 10 percent over the next 10 years.[38]

Town of Slave Lake

The Town of Slave Lake is the major population centre in the river basin. The present population served by the Town's water license is estimated at 7,311; this includes the town[39], the Poplar Lane subdivision (225)[40], and the Sawridge Indian Reserve (55)[41]. Average annual water use is estimated at 143 m^3 per capita based on average annual withdrawals from the Lesser Slave River (1997-2007).

Figure 10



The population growth rate for the Town of Slave Lake is projected to be 1.5 to 2.0 percent per year.[42] Based on present per capita usage, the volume of water that would be withdrawn from the Lesser Slave River is projected to be 1,343,433 m^3 per year by 2020.

Mitsue Industrial Park

Companies served by this water license, which is held by the MD of Lesser Slave River, include Tolko Industries, Vanderwell, Alberta Plywood (West Fraser Industries), CNR gas plant, Tiger Chemicals, CCS Industries and several smaller companies.

The volume of water withdrawn from the river for the industrial park has averaged 214,150 m^3 over the past ten years. The present industrial park infrastructure can support an expansion, including new resource-based and value-added process industries. The volume of water needed to support the anticipated growth could significantly increase the present licensed allocation.[43]

Summary

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[38] Mill Manager, Ranger Slave Lake Pulp, 2004.
[39] Community Profiles, Alberta Municipal Affairs, September 2008.
[40] Director of Operations, Town of Slave Lake, 2004.
[41] Aboriginal Census Data 2006.
[42] Director of Operations, Town of Slave Lake.
[43] Director of Field Services, MD of Lesser Slave River.

Annual withdrawals of water from the Lesser Slave River by the four major license holders are projected to increase by about 12 percent by 2020 (Figure 11).[44]

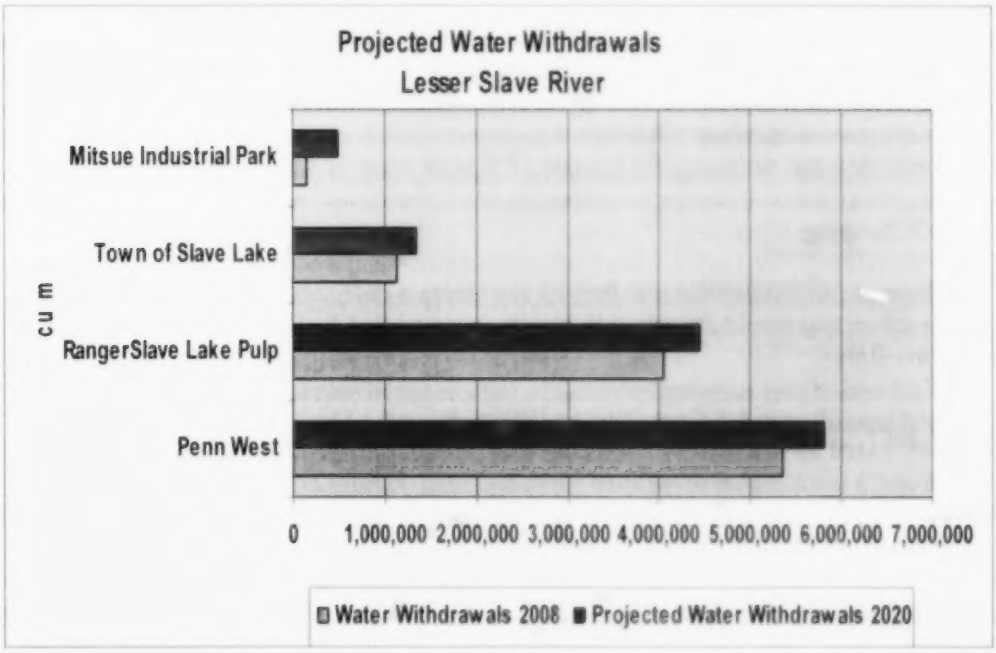

Figure 11

3.2 INSTREAM FLOW NEEDS FOR THE LESSER SLAVE RIVER

In Alberta full protection of the aquatic environment of rivers and streams is achieved through an assessment of in-stream flow needs (IFN). An IFN recommendation for the Lesser Slave River was intended to provide the benchmark in determining a Water Conservation Objective (WCO).

3.2.1 Definitions

Aquatic environment
The aquatic environment is defined by four inter-related elements: water quantity, water quality, habitat and aquatic species.

In-stream flow needs
That amount of water flowing through a natural stream course that is needed to sustain, rehabilitate, or restore the ecological functions of a stream in terms of hydrology, geomorphology, biology, water quality, and connectivity at a particular level[45]; or

[44] Projected water use for Penn West could change significantly if an alternate water source is found.
[45] Instream Flows for Riverine Resource Stewardship, Revised Edition, Instream Flow Council, 2004.

The scientifically determined flow rate that is required in a river to sustain a healthy aquatic environment or to meet human needs such as recreation, navigation, waste assimilation, or aesthetics.[46]

Water Conservation Objective

The *Water Act* defines a WCO (Sect. 1(1) (hhh) as..."the amount and quality of water necessary for: i. protection of a natural water body or its aquatic environment, or any part of them,
ii. protection of tourism, recreational, transportation or water assimilation uses of water, or
iii. management of fish or wildlife,
and may include water necessary for the rate of flow of water or water level requirements.

3.2.2 IFN Scoping

An interdepartmental committee was formed to develop a defensible, science-based IFN recommendation that would provide full, long-term protection to the aquatic ecosystem of the Lesser Slave River.

A detailed scope of work for conducting an IFN study on the Lesser Slave River was developed[47] based upon a review of existing data on ecosystem components. Data gaps were identified, and a work plan was outlined for completing additional field work needed to determine an IFN. A flow evaluation framework for assessing year-round in-stream flow needs was proposed based on the principles of the Instream Flow Incremental Methodology (IFIM).[48] IFIM quantifies the relative amounts of total available habitat throughout a network of stream segments for selected aquatic species under proposed alternative flow regimes; IFIM involves empirical measurements of hydrology, biology, water quality, channel morphology, and connectivity.

Given the lack of site-specific information on river ecosystem components, the interdepartmental committee also decided to evaluate an office-based method[49] (based on hydrology data) for developing an IFN recommendation for the Lesser Slave River. However, it was concluded that the use of the Alberta Instream Flow Needs Guideline (Appendix 1) to develop an IFN recommendation for a regulated system like the Lesser Slave River would not be appropriate, and that site-specific information on all components of the aquatic ecosystem would be required.

3.2.3 IFN Field Program for the Lesser Slave River

The recommendations of the scoping study form the basis of the IFN work plan and field program presently being implemented by the Lesser Slave Watershed Council. The IFN field program will address all components of the Lesser Slave River aquatic environment, and studies are in progress to fill data gaps identified in the scoping study. Completion of the field program as planned would allow an IFN to be recommended for specific segments of the Lesser Slave River, and would serve as a guide in achieving a balance between ecosystem services and economic considerations.

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[46] Water for Life, Alberta's Strategy for Sustainability, November 2003.
[47] Lesser Slave River Instream Flow Needs Scoping Study, Golder Associates, March 2004.
[48] The Instream Flow Incremental Methodology, U.S. Dept. of the Interior, Biol. Report 29, March 1995.
[49] Alberta Instream Flow Needs Guideline, Alberta Sustainable Resource Development, 2006.

3.3 SEDIMENTATION in the LESSER SLAVE LAKE OUTLET CHANNEL

The sedimentation of the river channel, in the segment upstream of the weir to the lake outlet, was identified as a public issue during the development of the terms of reference for the water management plan. It was perceived that this segment of the Lesser Slave River channel has been gradually infilling, to the extent that it could eventually impair the ability of recreational motorboats from navigating from the boat launch near the weir to the lake itself. This section of the plan presents an analysis of this issue in response to the public concern.

Background

The Environmental Impact Assessment prepared for the Lesser Slave Lake Regulation Project identified the following impacts on channel conditions in the Lesser Slave River upstream of the proposed weir:

1. "...some temporary increase in the amount of sand deposited on the (Lesser Slave Lake) Provincial Park beach, at the east end of the lake, may be experienced. Some additional sand will no doubt be carried into the Lesser Slave River."[50]
2. "...some stream bed adjustment can be expected with either the weir and cut-offs (alternative) or the canal and weir alternative."[51] There was no qualification of the nature of these anticipated adjustments.

In 1985, the Town of Slave Lake experienced problems with its water supply intake located on the Lesser Slave River. This intake had been installed in 1983 to replace a previous one at the same location. The earlier intake had experienced severe operational problems relating to sediment being drawn into the intake; this in turn resulted in excessive wear on the pumps. By 1985 the Town had noted similar problems and asked for advice from Alberta Environment; town officials suggested that a private breakwater constructed upstream of the intake and/or the Lesser Slave Lake Regulation weir was to blame for these problems.

In response to the concerns raised by the Town, the River Engineering Branch of Alberta Environment initiated a detailed assessment of the town's water supply intake, and conditions at the lake outlet and in the river channel upstream of the weir. The results of this assessment, including the information used and its conclusions, were documented in an Alberta Environment report.[52] This report concluded "the single most important factor in the sedimentation problem at the Town intake is considered to be an excess supply of sediment in the lake outlet from littoral drift in 1985, coupled with no relief of the problem in 1986. This is believed to have caused general deposition in the outlet area. Supplemental factors that have contributed to the problem are the volume of deposition occurring between the marina breakwater and the intake to

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[50] Lesser Slave Lake Regulation Environmental Impact Assessment, Volume 1, Main Report, page 28.
[51] Ibid, page 33.
[52] Assessment of Sedimentation Problems at the Town of Slave Lake Water Intake, Roger Drury, P. Eng. and Stephen Vincic, C.E.T., July 1987.

which both structures contribute, and the limited capacity of the intake structure to generate scour in the vicinity of the ports."[53]

Littoral drift is the movement of sediment along beaches by waves and currents. Littoral drift can be broken down into two classes: movement of sediment parallel to the shore (longshore transport) and; movement of sediment perpendicular to the shore (onshore-offshore transport). Either type may occur on a given beach depending on water levels, water currents, and wind direction and velocity. A more detailed discussion of sediment transport processes is contained in the report: *Sediment Sources and Movement in Lesser Slave Lake.*[54]

Figure 12

The aerial photograph (Figure 12) of the east end of Lesser Slave Lake (taken on July 6 1989) clearly shows the littoral drift processes. Areas of shallower water and where sediment is suspended in the water appear much lighter in the photo; deeper areas both in the lake and in the river channel appear darker in color.

The Town of Slave Lake made some modifications to their water supply intake to mitigate the sediment problem experienced in the mid-1980s.

Historical River Channel Surveys

In 1984, the year following the construction of the Lesser Slave Lake Regulation Project (weir and cutoff channels), Alberta Environment surveyed a series of cross sections of the Lesser Slave River. The purpose of the surveys was to establish a base line upon which future changes in channel depth and width could be compared. This was particularly important since the

[53] Ibid.
[54] Sediment Sources and Movement in Lesser Slave Lake, James Choles, P.Eng., River Engineering Branch, AENV, February 2001.

regulation project was designed to allow the river cutoff channels to increase their capacity (primarily in width), in order to increase outflow rates and reduce flood peaks and the drawdown time for water levels in the lake. Most of the sections downstream of the weir were subsequently re-surveyed in 1986, 1994 and 1998. About half of these sections were also surveyed in 1996. The river cross sections upstream of the weir were surveyed in 1984, 1993 and 1998; copies of the plots of the surveys upstream of the weir are provided in Appendix 4.

The surveys did not show any consistent aggradation (channel in-filling) or degradation (channel scouring); the pattern at most of the sections was aggradation between 1984 and 1993, and then degradation in the 1998 survey. Because there were only three surveys over this period it was difficult to make any definitive conclusions as to long-term trends.

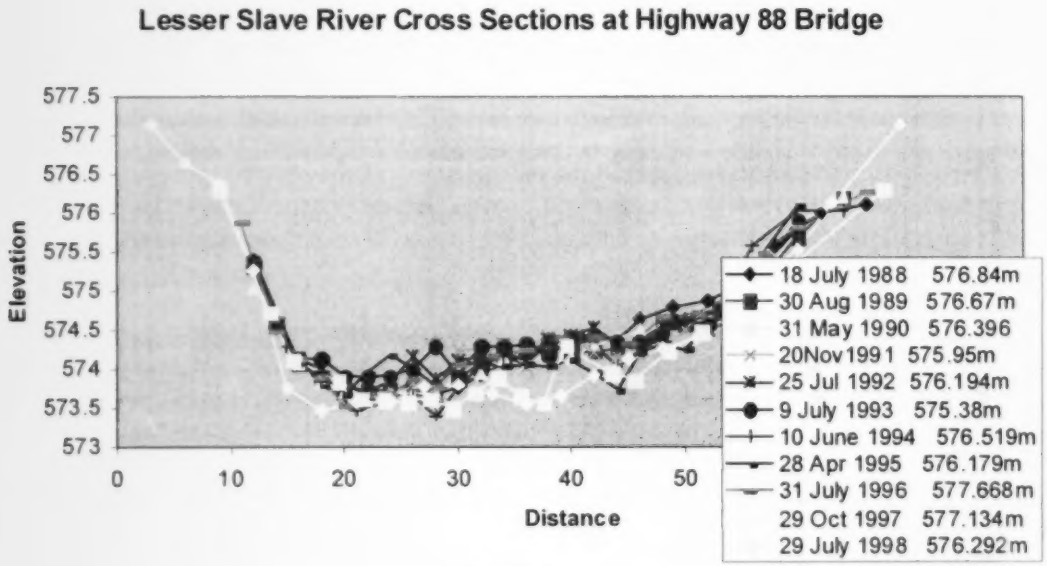

Figure 13

In order to better understand the river channel processes on an annual basis, cross section information obtained from Water Survey of Canada at their stream flow gauge site on the Lesser Slave River (Highway 88 Bridge), for the period 1988-1998, was evaluated. A review of the individual cross section plots (Figure 13) indicated the following:

1. No trend to either aggraded or degraded channel bed elevations;
2. Increases in bed elevation during periods of decreasing river flows;
3. Decreases in bed elevation during periods of increasing river flows; this was especially evident in the 1997 and 1998 surveys following the high water events of 1996 and 1997.

The physical processes occurring in the outlet channel can be explained by looking at the energy of the water flowing in the channel. All moving water has the ability to carry suspended sediment and the greater the velocity, the greater the energy potential. When the energy of the

flowing water decreases (i.e. the velocity decreases) then sediments will be deposited. This is illustrated in delta areas where the sediments carried by the river are deposited when the flow of water slows down upon entering the ocean or a lake. Similar processes occur along creeks and rivers as sediments are picked up or deposited, depending on flow velocities.

At the outlet of Lesser Slave Lake there exists a continual supply of sediment available to be transported to the Lesser Slave River by littoral drift. Depending on the velocity of river flows, the sediment can be transported all the way downstream (and into the Athabasca River) or the sediment can be deposited in various locations of the river channel. This process was clearly evident in the low flow conditions experienced in the fall of 1999 and again in the fall of 2006 (Figure 14). In both circumstances, the channel had to be dredged at the lake outlet to obtain sufficient flow in the river to enable the siphons to function.

Figure 14 Littoral Drift at the Lake Outlet

The problem of sediment deposition in the river channel is two-fold. Firstly, the sediment will restrict flows from the lake. Secondly, as the channel in-fills it creates navigational problems for recreational boaters as their props may "ground" out. This situation is exacerbated at low lake level conditions.

Alternatives

Basically there are two potential solutions to the problem of sediment deposition in the outlet channel. One alternative would be to restrict the movement of sediment to the river by constructing breakwaters perpendicular to the shore to block the movement of sediment into the channel. This would be a relatively expensive proposition due to the requirement to provide erosion protection for the breakwater in order to protect against wave action. In addition, the sediment that would be deposited behind the breakwater would eventually fill the area of

deposition and would then begin to move around the lake end of the breakwater; it would then be necessary to extend the breakwater further into the lake.

There would also be environmental impacts associated with this alternative. The shoreline would be altered significantly over time, although the impact would most likely be a change in the location of habitats rather than a loss of specific habitats. Also the breakwater would most likely be perceived as having negative aesthetics, especially with respect to the view from "The Point" restaurant. In light of the anticipated costs and other negative factors, this alternative was not pursued in detail and cost estimates were not developed.

A second alternative would be the initiation of some sort of dredging program on those occasions when conditions warrant. This was the case in 1999, and again in 2006, when flows were so low that dredging was required to enable flows to reach the siphons installed on the weir. In both years this dredging was undertaken by the MD of Lesser Slave River, with financial support from the Town of Slave Lake, Chevron (water license now held by Penn West), and Ranger Slave Lake Pulp, in order to maintain adequate flows for municipal and industrial water supply, and to maintain dissolved oxygen concentrations above water quality guidelines for the protection of aquatic life. The actual dredging operation was limited to a 100 m reach upstream from the Town of Slave Lake water intake; costs were in the order of $20,000.

Recommendations

1. Dredging of the channel at the lake outlet be carried out any time flows downstream are insufficient to provide the recommended minimum flow of 6 m^3 per second (Section 4.1); approvals would be required from both Alberta Environment and Fisheries and Oceans Canada.

2. Alberta Environment would be responsible for leading this process, including obtaining the necessary approvals, lining up the necessary equipment, and overseeing the actual dredging operation; costs of the dredging would be shared equally by the four major water license holders and Alberta Environment.

3.4 Weir Configuration Impacts: Whether the Lesser Slave Regulation Project Meets Present Needs

The issue of water levels in Lesser Slave Lake is a long-standing public concern. In 1999 low water levels in the lake created a public perception that the Lesser Slave Lake Regulation Project was not working the way it should. In particular, many people believed that something needed to be done to keep water levels in the lake from dropping too low.

A related public issue was the lack of a means in the existing weir that would provide some sort of minimal flow in the Lesser Slave River when lake levels drop to the elevation of the weir crest. When flow over the weir stopped in 1999, the MD of Lesser Slave River had to install siphons to accommodate flow over the weir to maintain sufficient flow in the river to meet the needs of downstream water users.

Potential solutions to each of these issues-lake water levels and river flows-are discussed separately in the following sections.

Regulation of Water Levels in Lesser Slave Lake

The major purpose of the Lesser Slave Regulation Project was to control water levels in the lake and provide flood relief to agricultural lands adjacent to the lake. The project design also considered the problem of low water levels during periods of drought; the problem was described in the Environmental Impact Assessment (1980) as follows:

"Fluctuating water levels have created problems for the residents of the area surrounding Lesser Slave Lake since the early 1900's. Alberta Environment files, dating back to 1920, recorded complaints from area farmers that high water levels that year were preventing the cutting of hay in the low lands surrounding the lake. There is also mention of the problem extending back to 1913 and a recommendation that the Lesser Slave River be channelized in order to increase the outflow from the lake. Since that time periodic episodes of high water have hampered agricultural operations around the lake. Records of water levels from 1914 to 1977 show a fluctuation range of 3.5 meters, from elevations of 575.3 to 578.9. It has been determined that 576.7 m is the elevation above which flooding of private land occurs. The lake level has exceeded this elevation 31 times between 1914 and 1967, with incidents of particularly high water levels occurring in 1920 (578.0 m), 1935 (578.9 m), 1936 (578.3 m), and 1965 (578.1 m). Lake levels have exceeded the 576.7 m elevation every year since 1971."[55]

The objective for the project, established in discussions with the Lesser Slave Lake Advisory Committee and by technical considerations, was to regulate the lake between the elevations of 577.6 m and 575.5 m. Several alternatives were investigated to achieve this objective for the lake; ultimately a modified weir and cut off scenario was selected on the basis of least costs and the probability of meeting the design objective (hydrologic modeling indicated that the high and low target levels would be exceeded less frequently).

Two follow up reports by Alberta Environment on the functioning of the regulation project indicated that the regulation project had in general met the original objectives.

The first assessment, completed in 1993, determined the water level requirements for different lake users and evaluated the impacts of the regulation project on agriculture, recreation, fisheries, and municipal water supply. This assessment determined that "the overall impact of the Lesser Slave Regulation Project is to reduce the range of long term water level fluctuations from 3.5 m to 2.7 m, and to reduce the frequency and the duration of both high and low water levels."[56] The second assessment of the regulation project was completed in 2002.[57]

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[55] Lesser Slave Lake Regulation Environmental Impact Assessment Volume 1, Main Report, AENV, April 1980, page 1.
[56] Lesser Slave Lake Regulation Status Report, AENV Planning Division, July 1993.
[57] Lesser Slave Lake Regulation Project Information Update, AENV, April 2002.

Flood events in 1996 (578.1 m) and 1997 (578.12 m), and very low levels in 1999 (575.4 m), once again raised public concerns about water levels of Lesser Slave Lake. In 1999 it was necessary to install siphons to maintain enough flow in the river for downstream water supplies, including effluent dilution. Following this event several individuals suggested that modifications be made to the existing regulation project to withhold water in the lake, so the stored water could be used to augment low flows in the future.

The Lesser Slave Watershed Committee examined possible modifications to the weir to mitigate the impacts of low water levels on recreational use of the lake, in particular boat access to the lake, and to ensure adequate river flows for downstream needs. One modification reviewed was the placement of a series of concrete blocks on top of the existing weir when the water level in the lake was low. The intent would be to restrict outflow from the lake during the August to January period, and thus store more water in the lake that could be released in the late January to May period. Alberta Environment evaluated this proposal and advised that the effect would be to raise the mean water level, and also the peak water level, of the lake.

To fully assess these suggestions and their impacts on lake levels, the Lesser Slave Watershed Council determined that additional modeling would be necessary. An integrated hydrology model for the Lesser Slave Basin was developed in 2008, and will be used to assess various water management scenarios for the lake as part of future water management planning.[58]

Regulating Flows in the Lesser Slave River

The Lesser Slave Watershed Committee also agreed on the need to examine means of ensuring adequate flows in the Lesser Slave River to meet existing and future water needs, including the need for protection of the aquatic environment.

No low flow structure was constructed as part of the Lesser Slave Lake Regulation Project as none was deemed necessary; the hydrologic modeling completed at the time indicated that water levels would not drop to the elevation of the weir crest.[59] Most dams and lake control weirs have provisions for some sort of minimum or riparian flow, and it is critical that a minimum flow be maintained at all times even when the gates must be fully closed for repairs and maintenance.

The Lesser Slave Watershed Council has identified the following options for augmenting low flows in the Lesser Slave River:

1. Future use of siphons;
2. Construction of a bypass channel/control culvert through the plug in the cut off at the weir;
3. Installing a riparian flow structure through the existing weir.

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[58] Development of an Integrated Hydrologic-Hydraulic Model for the Lesser Slave Basin, WorleyParsonsKomex, 2008.

[59] Lesser Slave Lake Regulation Environmental Impact Assessment, AENV, April 1980.

Option 1: Siphons

The use of siphons had been a cost effective option for the MD of Lesser Slave River for allowing flow past the weir in emergency, low-flow conditions. The siphons were installed using a portable crane and physical labor to place them at the weir; it was also necessary to prime the siphons in order to start their functioning. The costs[60] of siphons are presented in Table 2.

Description	1999/2000	2006/2007
Engineering	$ 21,532.90	$ 32,728.20
Channel dredging	$ 61,239.99	$ 88,425.17
Manufacture, installation and removal of siphons	$ 21,673.61	$ 19,707.97
Weir construction	$ 47,032.61	
Total Cost	$162,082.63	$140,861.33

Table 2

Following the removal of the siphons in 2007, it was noted that a number of them had deteriorated and their elements would have to be replaced. Replacement costs using higher quality materials would cost $6,800 per siphon, making the total replacement cost for seven siphons $47,600.

As discussed in Section 3.3, under low flow conditions sediment is deposited in the river channel at the lake outlet; this infilling of the channel further restricts outflow from the lake. Under low lake water level scenarios, it is likely that the control of outflow from the lake shifts from the weir to the restricted channel upstream. It is necessary that the channel be dredged from the main body of the lake to the river channel to enable sufficient flow to reach the siphons and allow them to function; this scenario would be required no matter which alternative was selected to accommodate flows past the weir.

The future use of siphons to maintain flows in the river under low flow conditions is <u>not</u> recommended for the following reasons:

- The siphons are somewhat dangerous to install.
- The siphons require longer lead times for installation and commissioning.
- The existing siphons are badly damaged and most need to be replaced.

Option 2: Gated Culvert

[60] MD of Lesser Slave River

The second option for providing minimum or riparian flows in the Lesser Slave River, during low lake level conditions, would be the placement of gated culverts through the plug in the old river channel that could be opened and closed as required. This structure would be similar to the control culverts used in irrigation systems. The photo on the right is an example of what the gated culvert would look like.

A conceptual design and cost estimates have been developed for this option. The conceptual design is based on an in-office analysis using existing information. A field survey and detailed analysis would be needed to confirm the assumptions used.

The reach of channel where the culverts would be located is relatively flat and since these culverts would be used primarily during low water level conditions, they would be functioning under outlet control conditions and consequently would not function as efficiently as normally would be expected. To achieve the recommended minimum flow of 6 m^3 per second (Section 4.1), it would be necessary to install two 1.5 meter diameter corrugated steel pipes. In the event that sufficient head water cannot be achieved, it would be necessary to install a third culvert. The cost of installing these pipes is summarized in Table 3; the costs are based on Alberta Infrastructure costs for recently installed culverts.

Component	Number	Unit Cost	Total Cost
1.5 meter diameter csp	63	$ 282.00	$ 17,766.00
1.5 meter diameter flow gate	3	$ 5,000.00	$ 15,000.00
Couplers	6	$ 130.00	$ 780.00
Excavation and installation back hoe		Lump sum	$ 5,000.00
Excavation and installation labor		Lump sum	$ 1,000.00
Contingency 30%			$ 11,863.80
Total			**$ 51,409.80**

Table 3 Costs of Culvert Installation in the Old Channel of the Lesser Slave River

Option 3 Riparian Flow Structure

The third option of installing a riparian flow structure through the existing weir was not pursued due to the physical nature of the weir structure and the difficulties modifying the existing structure would create. The existing structure has a concrete apron placed over pit run fill directly in front of the sheet pile weir, and it would be extremely difficult to place a pipe through for the purposes of providing a low flow structure.

Recommended Option

It is recommended that Alberta Environment proceed with the design and construction of the gated culverts required to provide a minimum flow of 6 m^3 per second in the Lesser Slave River.

4.0 PLAN RECOMMENDATIONS

4.1 Minimum Flow Recommendation

The Lesser Slave Watershed Council recommends that a minimum flow of 6 m^3 per second be maintained in the Lesser Slave River to ensure a sufficient water supply for municipal and industrial uses, including the dilution of effluents, and to maintain concentrations of dissolved oxygen above water quality guidelines for the protection of aquatic life.

The minimum flow recommendation is based primarily upon the assessment of river flow and water quality during the low flow conditions of 1999-2000.[61]

4.2 Low Flow Operational Response Procedures

The Lesser Slave Watershed Council recommends that Alberta Environment take the lead role and responsibility for implementing operational procedures for ensuring that the recommended minimum flow of 6 m^3 per second is maintained in the Lesser Slave River.

The recommended operational response procedures are outlined in Table 4. They involve dredging of the channel at the lake outlet whenever flows downstream are insufficient to provide the recommended minimum flow, and are contingent upon Alberta Environment proceeding with the design and construction of the gated culverts to accommodate flow in the river channel downstream of the weir.

Appendix 2 provides a rationale for the recommended operational response procedures.

Table 4 Proposed Low Flow Operational Procedures

Step	Responsible Party
Initiate operational response procedures if water levels in Lesser Slave Lake are below 576.2 m on September 1 in any given year.	Alberta Environment Lesser Slave Watershed Council
Assess the risk of flows in the Lesser Slave River dropping to levels where an operational response is required: • Review water level trends.	

[61] Low Flow Conditions in the Lesser Slave River, AENV, August 2000.

• Review long range precipitation forecasts. • Assess channel depth (depth finders/physical surveys) in the river segment from the weir to the lake outlet.	Alberta Environment
Apply for an approval under the *Water Act* to dredge the river channel at the lake outlet if the risk assessment indicates a probability for water levels in the lake to drop to 575.7 m during the winter.	Alberta Environment, Water Management Operations
Complete, by September 25, an assessment of the discharge capacity of the lake outlet and the projected capacity over the winter.	Alberta Environment
Initiate dredging if the discharge capacity of the outlet is expected to drop below 15 m^3 per second. Recommend use of a suction dredge to pump the removed material on shore into environmental pads.	Alberta Environment to lead in a partnership (MD of Lesser Slave River, Town of Slave Lake, Ranger Slave Lake Pulp, PennWest Energy) to share costs.
Initiate enhanced monitoring of dissolved oxygen concentrations in the Lesser Slave River when flow drops below 12 m^3 per second.	Alberta Environment
Open the gated culverts when the flow in the Lesser Slave River drops to 6 m^3 per second.	Alberta Environment-Lead
Assess the effectiveness of the operational procedures and results of monitoring in June of the following year.	Alberta Environment-Lead

4.3 Maintenance of a Navigable Channel at the Lesser Slave Lake Outlet

The Lesser Slave Watershed Council recognizes the need for a navigable channel to be maintained in the Lesser Slave Lake outlet so that commercial and recreational marine craft can access the lake from the public boat launch and private marina located in the Lesser Slave River above the weir. The Watershed Council recommends that Navigable Waters Canada consider the specific navigational needs in these waters within the context of its overall legislative responsibility for the protection of the public right to navigation and the protection of the environment.

4.4 Long Term Water Quality Monitoring Station

The Lesser Slave Watershed Council recommends that a permanent water quality monitoring station be established on the Lesser Slave River. The Lesser Slave is currently the only major watershed in the province that is not part of the long term river network (LTRN). The development of a River Water Quality Index for the Lesser Slave River would provide a measure of the effectiveness of watershed management efforts to improve the health of the watershed.

4.5 Instream Flow Needs Field Program

The Lesser Slave Watershed Council has undertaken a field program (Appendix 3) in order to collect sufficient information to better understand the long-term consequences of future water management decisions, including the recommended 6 m^3 per second minimum flow objective, on the aquatic environment of the Lesser Slave River.

Completion of the field program and work plan would allow the Watershed Council to develop a science-based IFN recommendation that would provide long-term protection of the Lesser Slave River aquatic ecosystem. It is recommended that funds from Alberta Environment, in conjunction with implementation of the *Water for Life* strategy, would continue to be provided to allow timely completion of the field program.

Developing an IFN for key segments of the Lesser Slave River would provide the benchmark for a Water Conservation Objective (WCO) recommendation. Developing a WCO recommendation would involve assessing the volume of water required for human uses, including existing consumptive and non-consumptive water uses, and the river flow and quality needed to protect the aquatic environment. The Lesser Slave Watershed Council would consider the economic and social needs and values of stakeholders and the public, and the ecological water needs of both the lake and the river, in the process of developing the WCO recommendation.

5.0 REFERENCES

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APPENDIX 1

Application of the Alberta Instream Flow Needs Guideline-Lesser Slave River

The Alberta Instream Flow Needs Guideline is a province-wide guideline for setting instream flow requirements. It accounts for the natural flow paradigm, preservation of the natural flow variability and ecological function of a river system, that considers the importance of the natural

timing and variability of flows within and between years, and that considers all components of the river ecosystem.

The guideline provides a method for making a flow recommendation when: a) site-specific IFN information is lacking; and b) the objective is to provide full protection of the aquatic environment. The guideline does not make trade-offs between ecosystem components and is based from natural flows (the greater of either 85 percent or natural or 80 percent exceedance).

For the Lesser Slave River, the guideline is useful only as a 'scoping' tool to suggest where flows do or do not provide for full protection of the aquatic environment. The guideline cannot be used to make flow recommendations for a regulated system like the Lesser Slave River where the single objective of full protection of the aquatic environment no longer exists, due to trade-offs between water users and instream flows and trade-offs for maintaining lake water levels within a certain range vs. maintaining natural flows in the river.[62]

For a regulated system like the Lesser Slave River, the use of the guideline is not appropriate, and site-specific information is required. Therefore, as recommended by the scoping study, an IFN field program has been initiated by the Watershed Council that will address all components of the Lesser Slave River ecosystem (Appendix 3).

Application of the Alberta IFN Guideline-Lesser Slave River

[62] Alberta Sustainable Resource Development, Fish and Wildlife, personal communication with IFN Biologists 2008

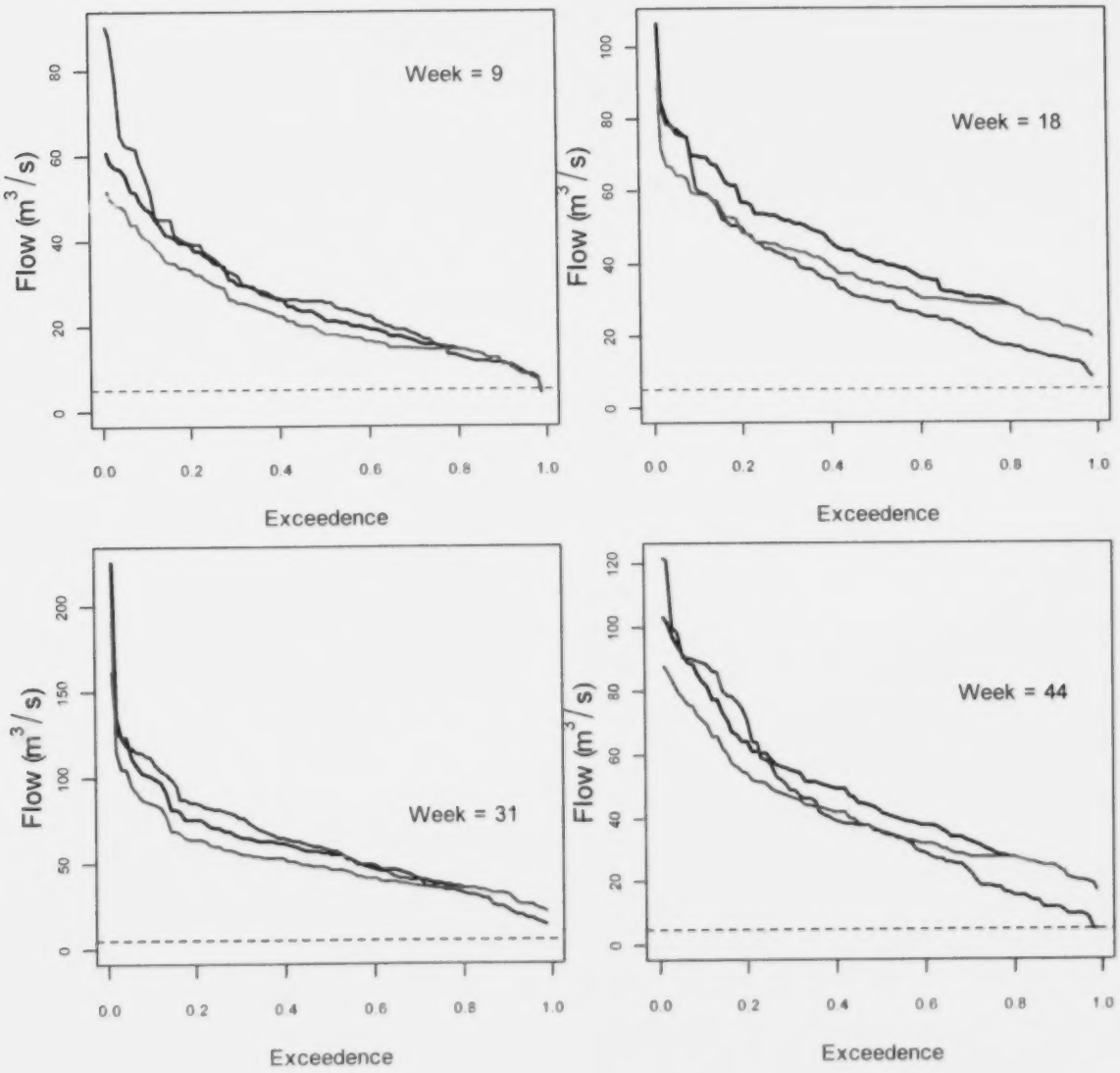


Figure 1 – Flow exceedence plots for the Lesser Slave River near the Town of Slave Lake. Black lines are natural flows (without weir or channel cut-offs), red lines are regulated flows (with weir and cut-offs), and, green lines are the Alberta Desktop guideline applied to natural flows (the greater of either 85% natural or 80% exceedence). Plots are shown for different weeks of the year and correspond to a winter (week 9), spring (week 18), summer (week = 31) and fall (week = 44) flow period. The dashed line is at 5 cms. Natural flows for the period 1916-1979 were based on either: a) observed discharge from the 07BK001 gauge when available; or, b) simulated values from the lake level-river flow rating curve. For the period 1980-2005 (construction and completion of weir and cut-offs), natural flows were based only on simulated values from the ratings curve. Regulated flows for the period 1916-1983 are simulated values using the lake level-river discharge rating curve (with the weir and cut-offs installed). For the period 1984-2005, regulated discharge was determined from the 07BK001 gauge when available or simulated values, otherwise.

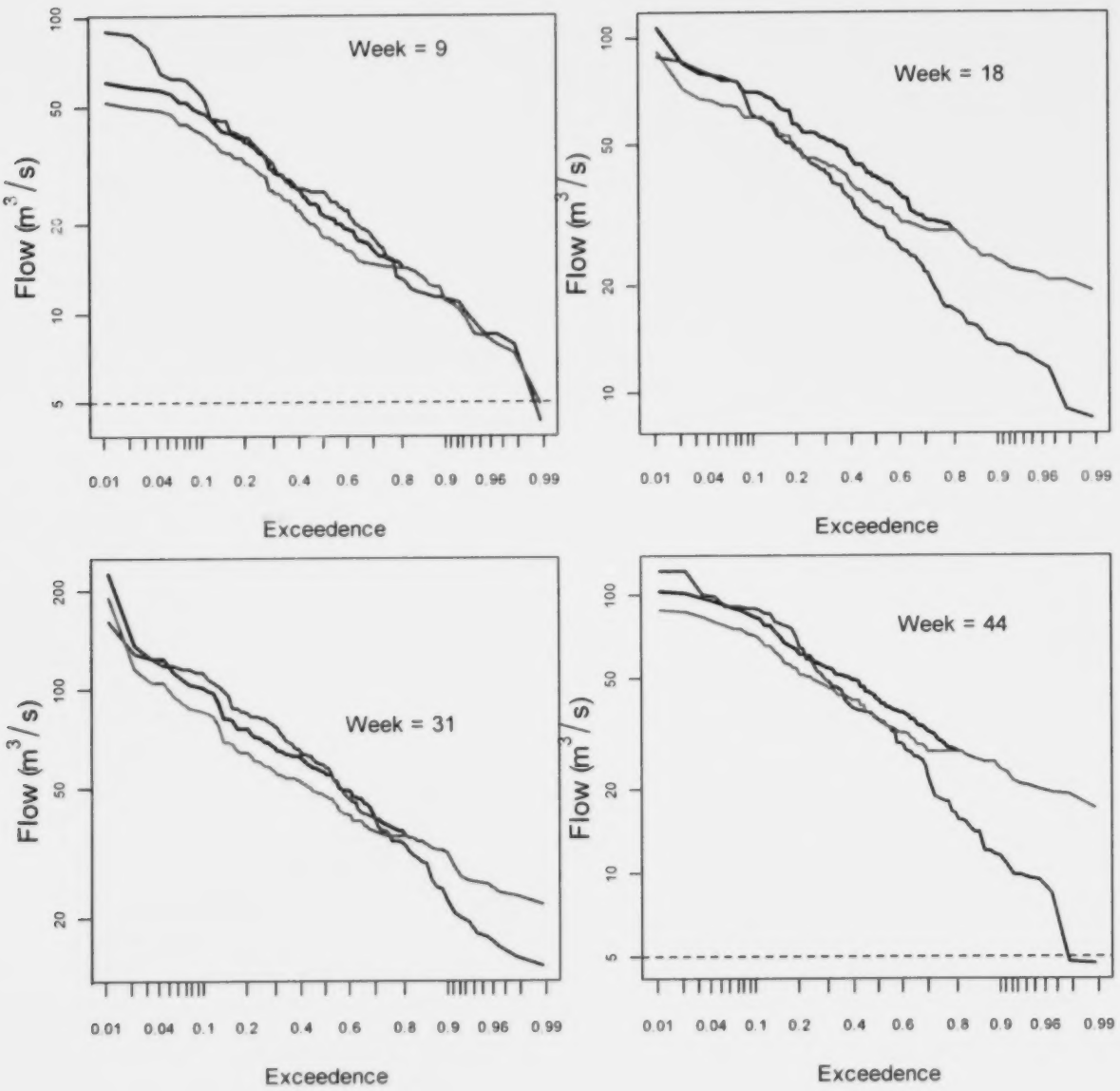


Figure 2 – Log-normal flow exceedence plots for the Lesser Slave River near the Town of Slave Lake. Black lines are natural flows (without weir or channel cut-offs); red lines are regulated flows (with weir and cut-offs); and, green lines are the Alberta Desktop guideline applied to natural flows (the greater of either 85% natural or 80% exceedence). Plots are shown for different weeks of the year and correspond to a winter (week 9), spring (week 18), summer (week = 31) and fall (week = 44) flow period. The dashed line is at 5 cms. Natural flows for the period 1916-1979 were based on either: a) observed discharge from the 07BK001 gauge when available; or, b) simulated values from the lake level-river flow rating curve. For the period 1980-2005 (construction and completion of weir and cut-offs), natural flows were based only on simulated values from the ratings curve. Regulated flows for the period 1916-1983 are simulated values using the lake level-river discharge rating curve (with the weir and cut-offs installed). For the period 1984-2005, regulated discharge was determined from the 07BK001 gauge when available or simulated values, otherwise.

APPENDIX 2

Rationale for Low Flow Operational Response Procedures

For two periods in the last 25 years flows in the Lesser Slave River have dropped to zero at the weir. The tables below provide data for both of these events.

Lesser Slave Lake Daily Water Levels 1999

Date	Elevation (meters)	Comment
Aug 1	575.959	
Sep 1	575.891	
Nov 1	575.752	
Nov 10	575.655	
Nov 11	575.658	
Nov 12	573.714	
Nov 13	575.684	
Nov 14	575.664	
Nov 15	575.612	
Nov 16	575.683	
Nov 17	575.668	
Nov 18	575.693	
Nov 19	575.640	
Nov 20	575.646	
Nov 21	575.598	
Nov 22	575.516	
Nov 23	575.482	
Nov 24	575.455	
Nov 25	575.429	
Nov 26	575.605	
Nov 27	575.622	
Nov 28	575.574	
Nov 29	575.589	
Nov 30	575.671	
Dec 1	575.669	
Dec 2	575.665	

Nov	Mean	575.632
	Max	575.752
	Min	575.429
Dec	Mean	575.682
	Max	575.701
	Min	575.642

Lesser Slave Lake Daily Water Levels 2006

Date	Elevation (meters)	Comments
Aug 1	576.309	
Sep 1	576.174	
Oct 1	576.130	
Oct 20	576.058	
Oct 21	576.018	
Oct 22	575.944	
Oct 23	576.033	
Oct 24	576.013	
Oct 25	576.057	
Oct 26	576.102	
Oct 27	576.054	
Oct 28	576.024	
Oct 29	576.079	
Oct 30	576.084	
Oct 31	575.816	
Nov 1	575.606	
Nov 2	575.534	Emergency response starts
Nov 3	575.431	Dredging starts
Nov 4	575.561	
Nov 5	575.776	
Nov 6	575.695	
Nov 7	575.771	
Nov 8	575.943	Dredging completed
Nov 9	575.886	
Nov 10	575.858	
Nov 11	575.917	
Nov 12	575.891	
Nov 13	574.901	
Nov 14	575.910	
Nov 15	575.877	Siphons started

Oct	Mean	575.632
	Max	576.130
	Min	575.816
Nov	Mean	575.859
	Max	575.964
	Min	575.431

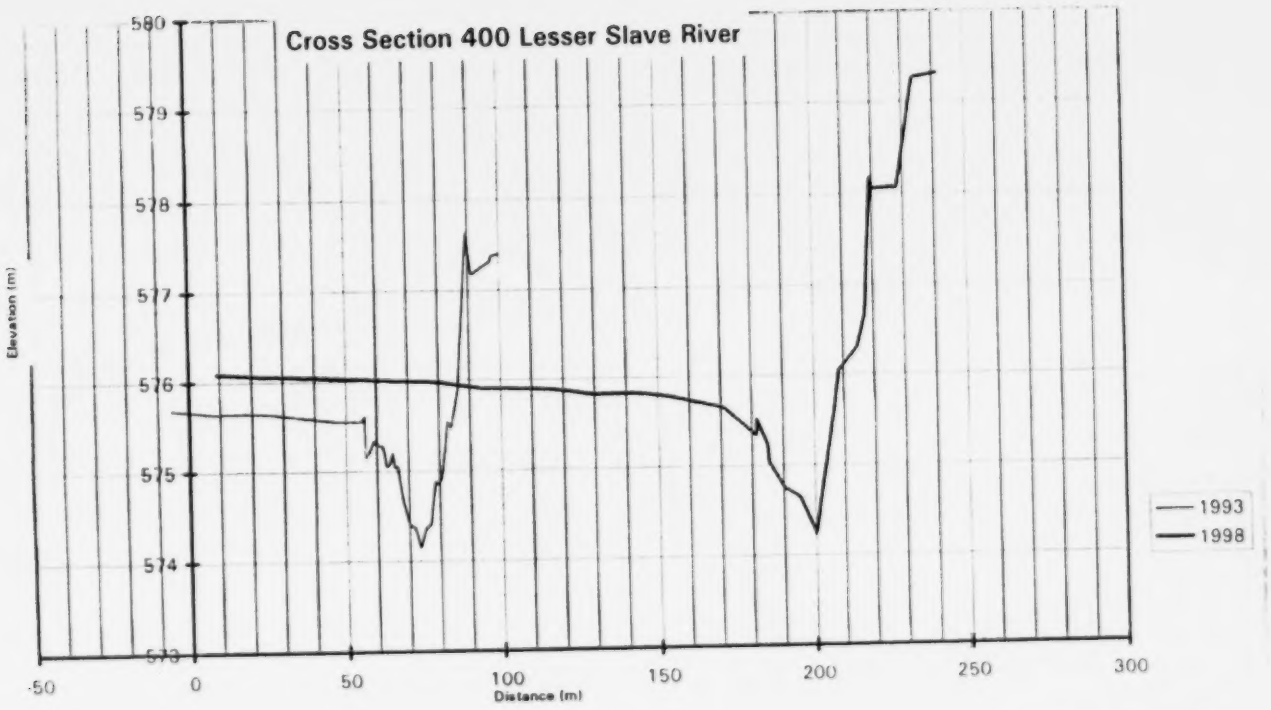
APPENDIX 3

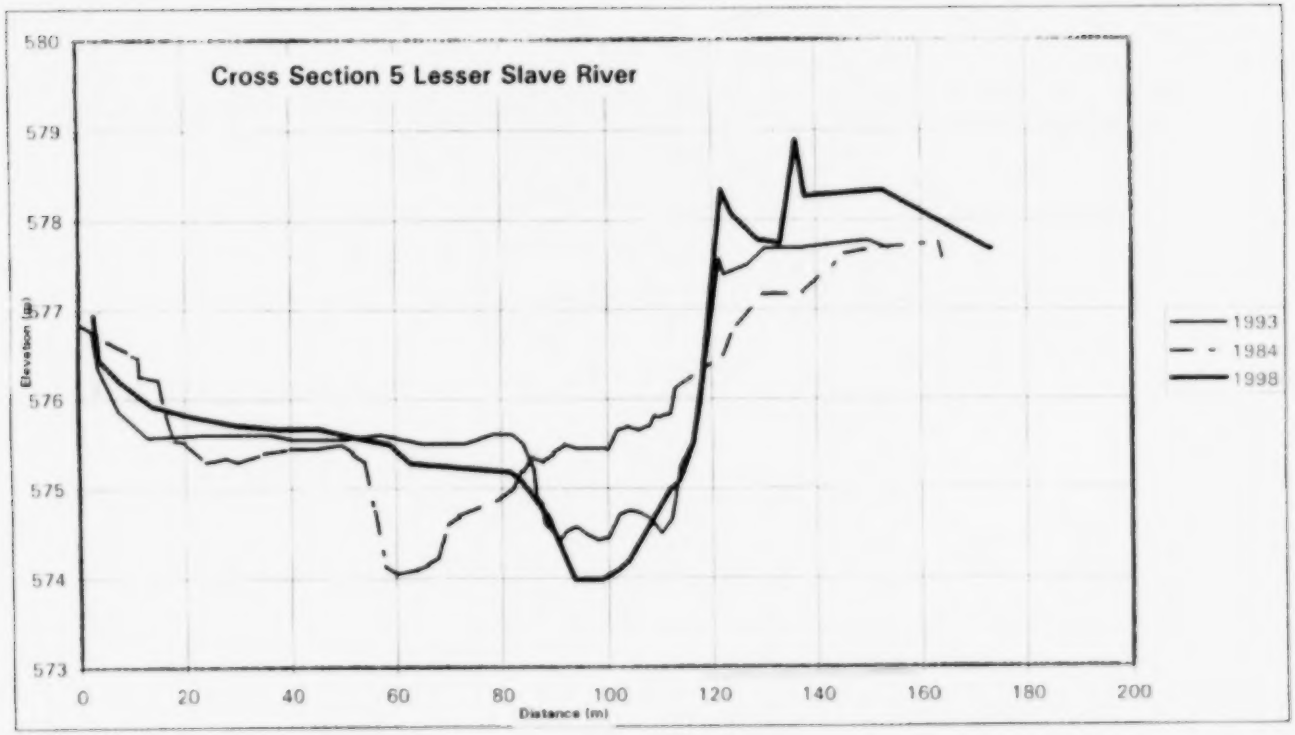
Lesser Slave Watershed Council - IFN Work Plan

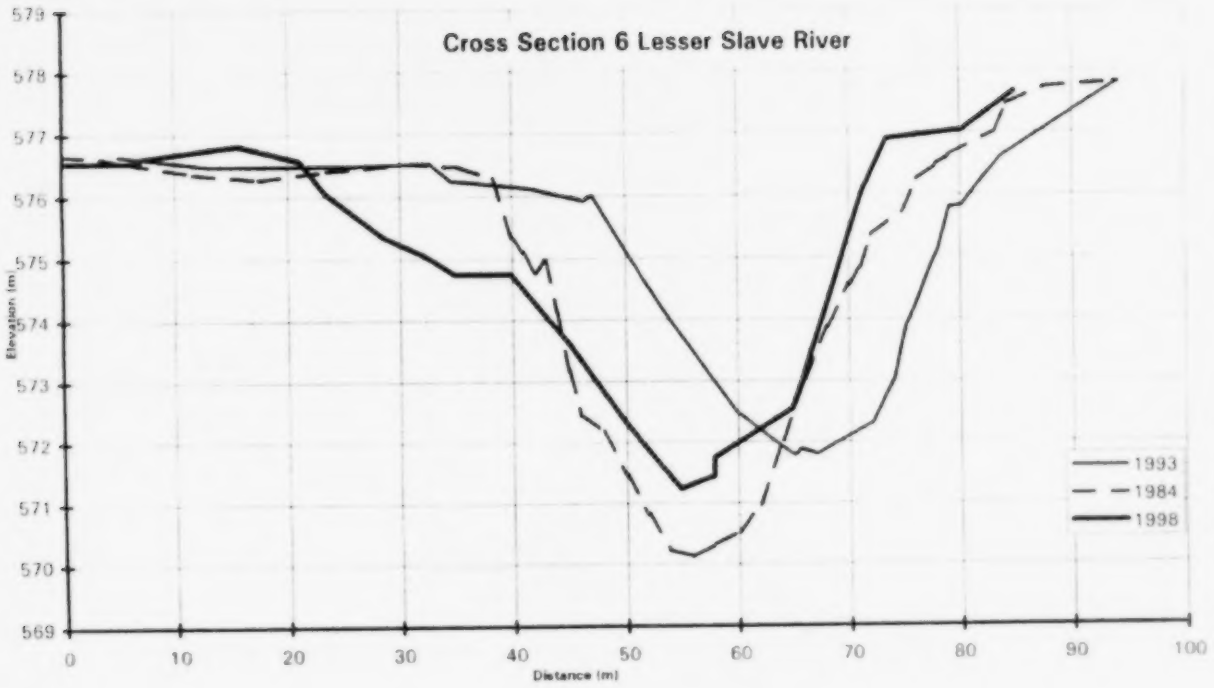
	Project Status
Hydrology	
Integrated Hydrologic Model - Watershed	Contract completion - 2008
Morphology	
Ice Monitoring – LS River	Completed by Fish & Wildlife - 2007
GIS Tool (assess existing accuracy)- LS Lake	Completed by SRD Mapping Unit-Peace River - 2008
Shoreland Elevations – LS Lake	Lidar Survey by SRD – Sep 2008
Bathymetry Update - LS Lake	Proposed contract - 2009
Water Quality	
Integration of WQ model for IFN – LS River	Proposed completion by AENV - 2009
Biology	
Riparian Assessment - LS River	Proposed project – 2009
Invertebrate Assessment - LS River	Proposed project - 2009
Fish winter use - LS River	Completed by Fish & Wildlife - 2007
Mesohabitat mapping - LS River	Completed by Fish & Wildlife - 2007
Hydraulic Surveys Open-Water - LS River	Contract completed for Saulteaux-Driftwood segment – 2008; contract proposed for additional river segments – 2009/10
Hydraulic Surveys Ice-Covered - LS River	Contract completed for Saulteaux-Driftwood segment – 2008; contract proposed for additional river segments – 2009/10
Hydraulic modelling - LS River	Contract completed for Saulteaux-Driftwood segment - 2008
Hydraulic Surveys Spawning - S. Heart	Contract completed - 2008
Hydraulic Modelling - S. Heart	Contract completed - 2008
Mesohabitat analysis - LS River	Fish & Wildlife - 2009
Spawning Habitat analysis - S. Heart	Fish & Wildlife - 2009
Habitat Workshop - Rivers	
Fish Population Data - LS Lake	Fish & Wildlife - 2007
Fish Population Analysis - LS Lake	Fish & Wildlife - 2008
Habitat Workshop - LS Lake	
Connectivity	
Cut-off Channel Assessment	Fish & Wildlife – 2009/10
IFN Integration	
IFN Determination Report	2010/11

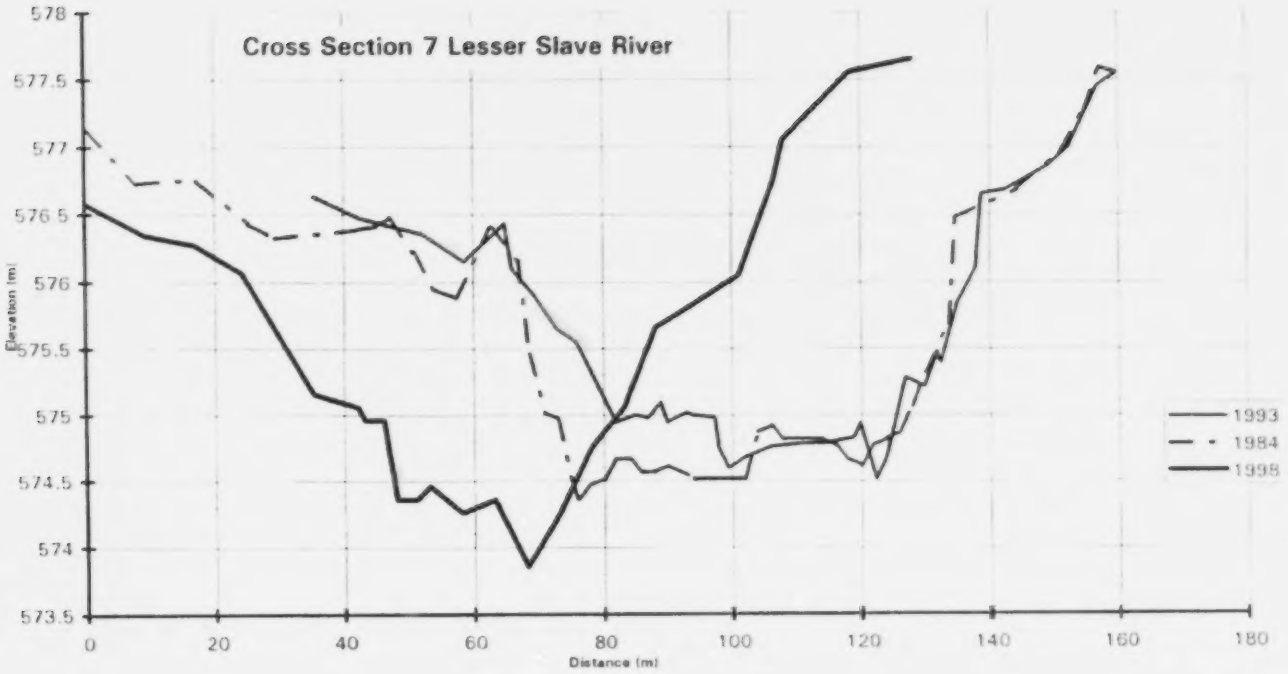
APPENDIX 4

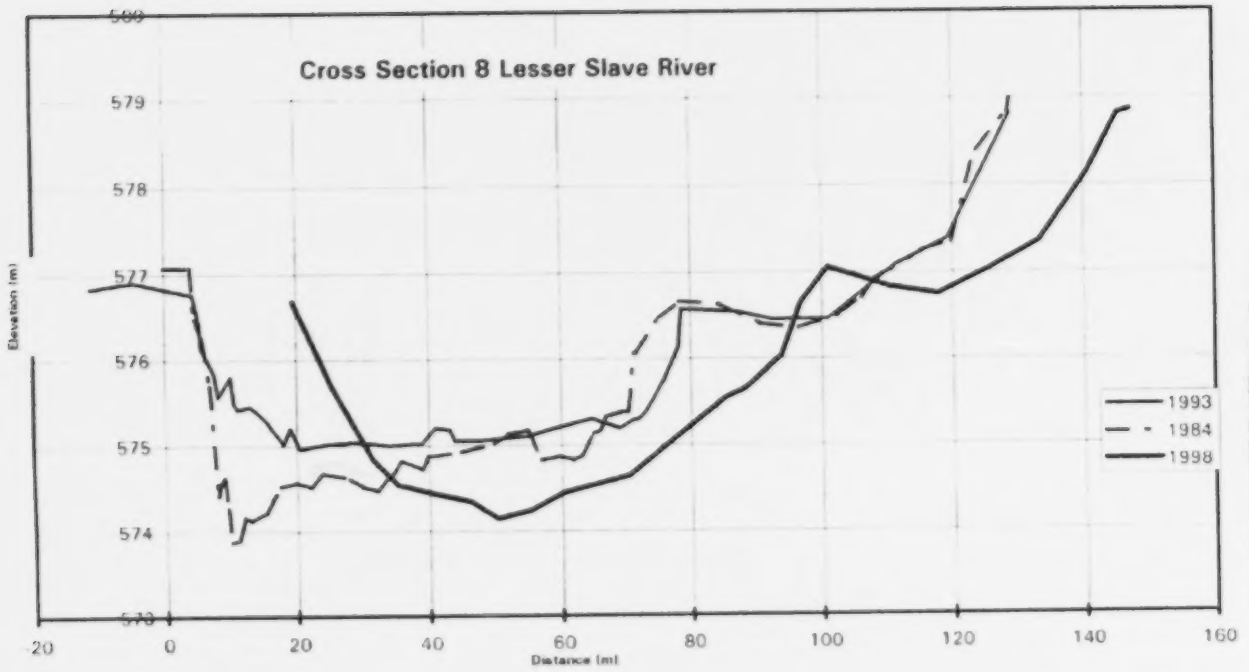
Lesser Slave River Cross Sections


Cross Section 400 Lesser Slave River
Elevation (m)
580
579
578
577
576
575
574
573
-50
0
50
100
150
200
250
300
Distance (m)
1993
1998

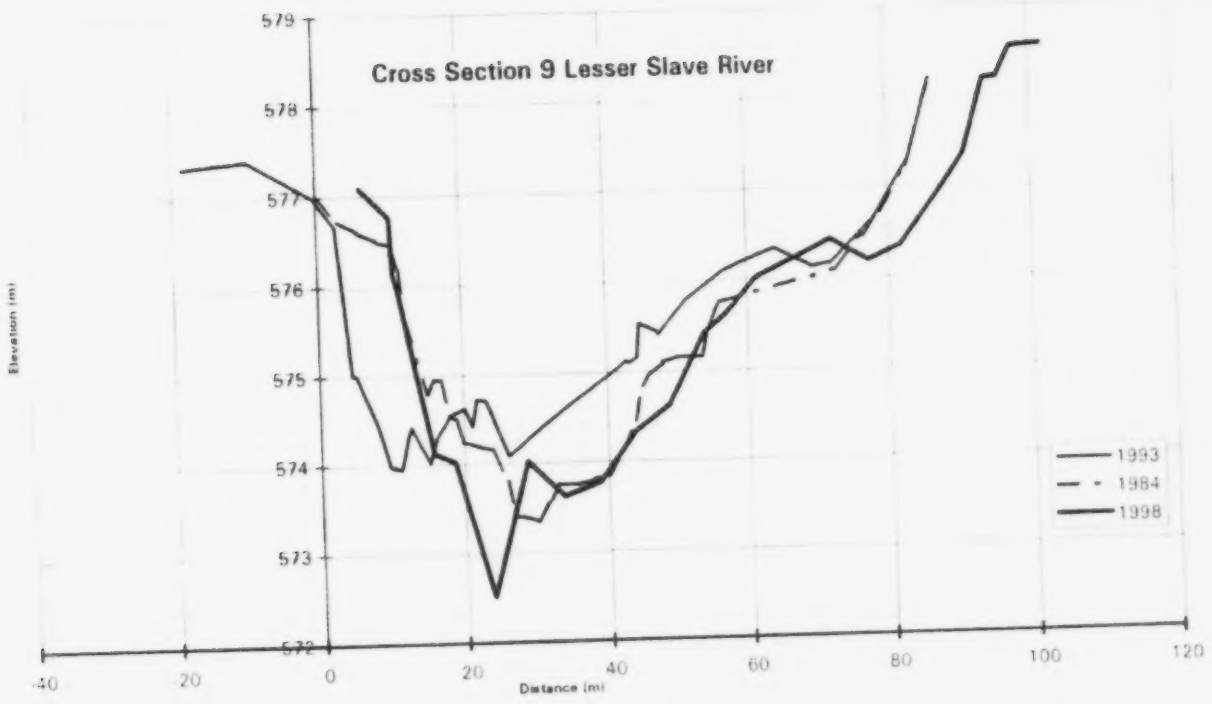

Cross Section 5 Lesser Slave River
580
579
578
577
576
575
574
573
Elevation (m)
0
20
40
60
80
100
120
140
160
180
200
Distance (m)
1993
1984
1998


Cross Section 6 Lesser Slave River
Elevation (m)
579
578
577
576
575
574
573
572
571
570
569
0
10
20
30
40
50
60
70
80
90
100
Distance (m)
1993
1984
1998


Cross Section 7 Lesser Slave River
578
577.5
577
576.5
576
575.5
575
574.5
574
573.5
Elevation (m)
0
20
40
60
80
100
120
140
160
180
Distance (m)
1993
1984
1998


Cross Section 8 Lesser Slave River
Elevation (m)
579
578
577
576
575
574
20
0
20
40
60
80
100
120
140
160
Distance (m)
1993
1984
1998

XSECT9(98).XLC



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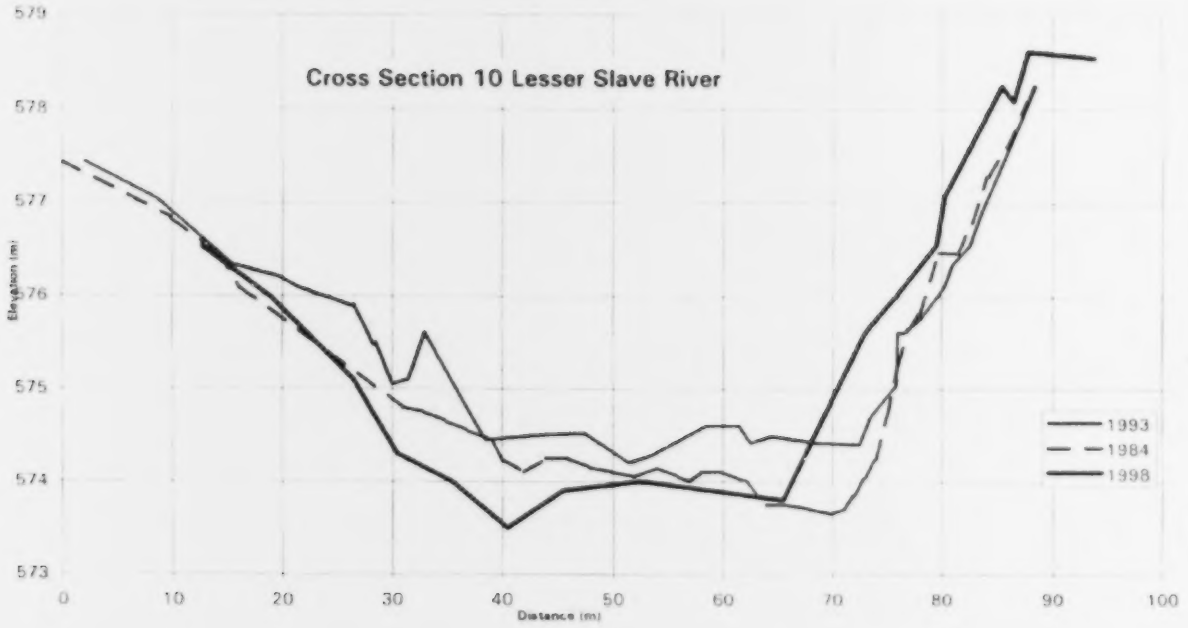

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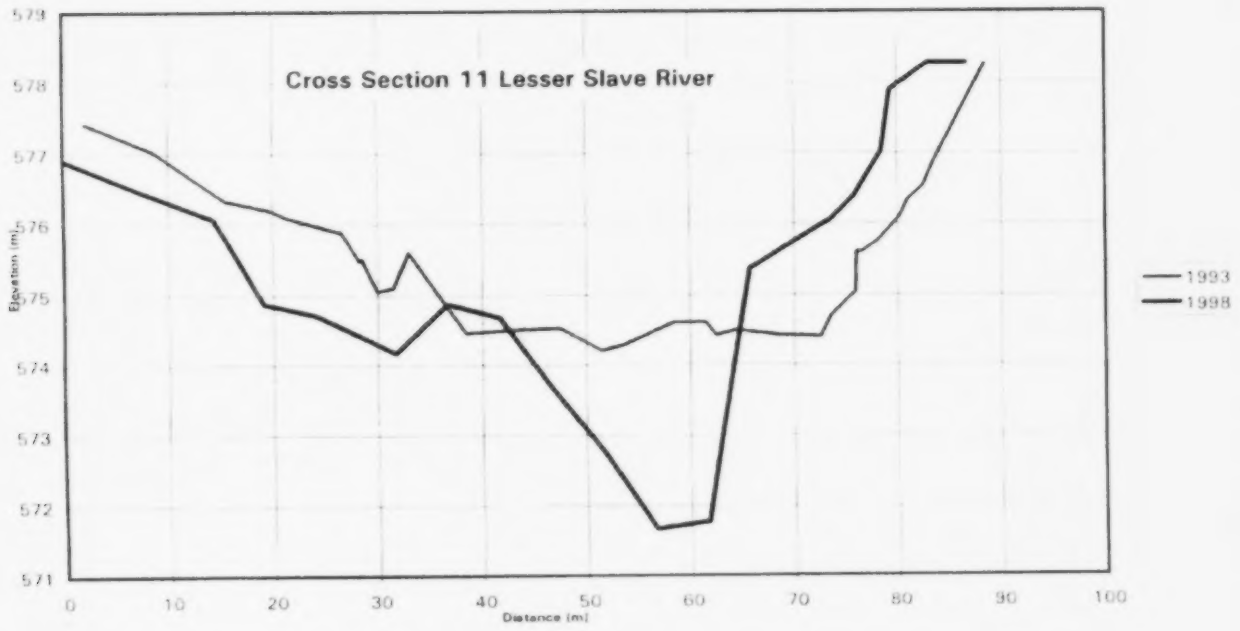

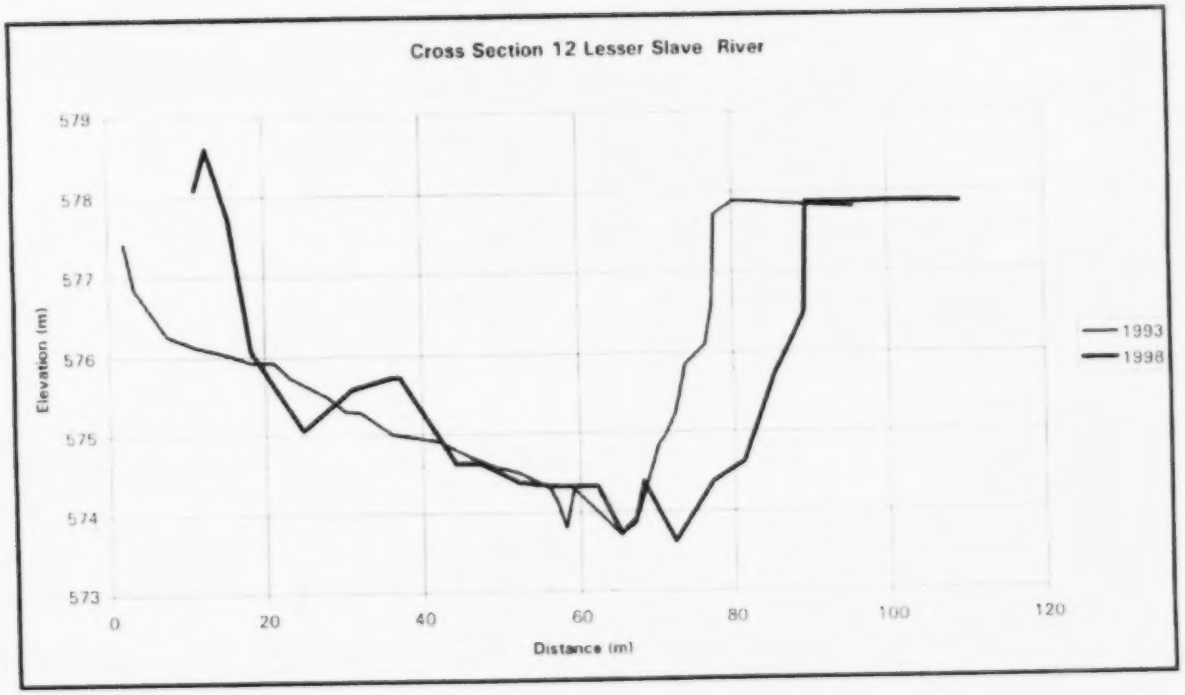
Cross Section 12 Lesser Slave River
579
578
577
576
575
574
573
Elevation (m)
0
20
40
60
80
100
120
Distance (m)
1993
1998

Slave River Cross Section Comparison
Cross Section #13
578.5
578
577.5
577
576.5
576
575.5
575
574.5
574
573.5
573
Elevation (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
Distance (m)
1994
1986
1984
1998